JOURNAL
OF
THE FRANKLIN INSTITUTE
DEVOTED TO SCIENCE AND THE MECHANIC ARTS

VOL. CLXXV JUNE, 1913 No. 6

THE PRODUCTION AND DISTRIBUTION OF ENERGY.*

BY

SAMUEL INSULL,

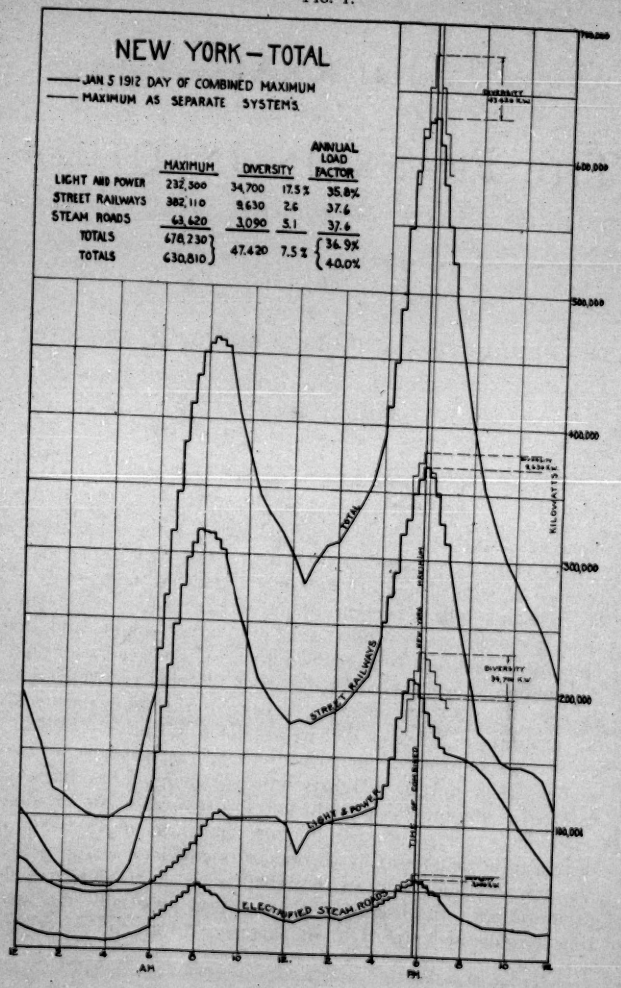
President Commonwealth Edison Company, Chicago.
Member of the Institute.

(President Clark, in introducing the speaker, briefly sketched the rapid development of Chicago's electrical interests, giving figures and data, and referred to the active part taken in such development by Mr. Insull.)

MR. PRESIDENT AND GENTLEMEN: The figures that have been so ably presented are certainly somewhat staggering. I do not think I have ever heard them presented in exactly the same form before. Whilst it is my duty to-night, and my pleasure, to address you on the subject of the generation and distribution of energy—or I will correct that and say "electrical energy"—I have no intention, except in the most incidental way, to refer to the work that we are doing in Chicago. Whenever I have addressed a similar body to this on the subject of the economical production and distribution of energy I have usually referred to the means of production in great cities and the distribution of energy for use in those cities, and have tried to demonstrate that the truly economical method to pursue is the manufacture and distribution of all such energy under one organization. In discussing this subject, especially the last time I addressed myself to it,—namely, before the American

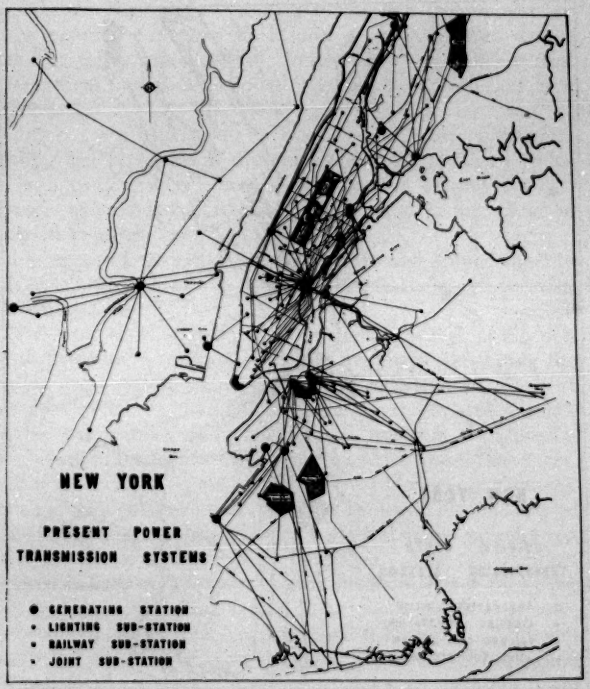
*Presented at the stated meeting held Wednesday, March 19, 1913.

FIG. 1.


NEW YORK — TOTAL
JAN 5 1912 DAY OF COMBINED MAXIMUM
MAXIMUM AS SEPARATE SYSTEMS
MAXIMUM
DIVERSITY
ANNUAL LOAD FACTOR
LIGHT AND POWER 232,300 34,700 17.5% 35.8%
STREET RAILWAYS 382,110 9,630 2.6 37.6
STEAM ROADS 63,620 3,090 5.1 37.6
TOTALS 678,230 47,420 7.5% 36.9%
TOTALS 630,810 40.0%
TOTAL
STREET RAILWAYS
LIGHT & POWER
ELECTRIFIED STEAM ROADS
KILOWATTS
AM
PM

Institute of Electrical Engineers, about a year ago,—I have referred to the necessity of having very large prime movers, a necessity which undoubtedly exists, in order to get economical production in large cities; but this evening I propose to give my

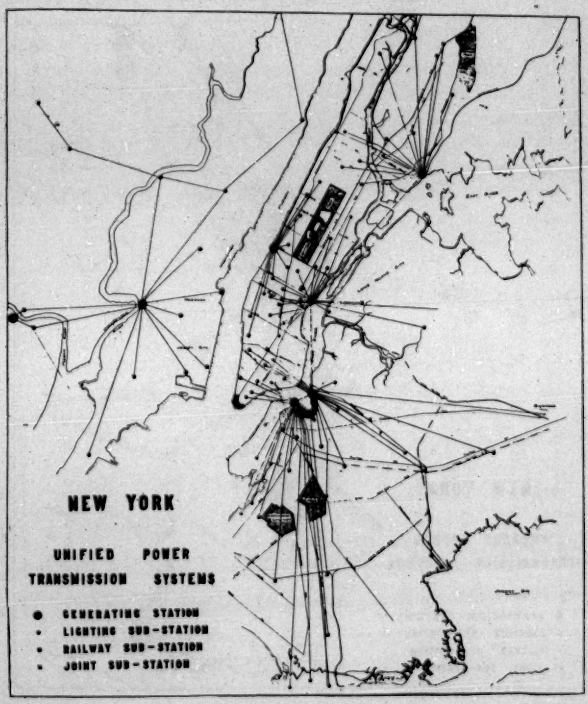
FIG. 2.



attention—and to ask you to give your attention also—to exactly the opposite viewpoint. I propose to take the smallest prime movers that I have had anything to do with in the smallest generating stations in the rural and agricultural territory of Illinois, and, starting from that point, to draw your attention to the

various uses to which electrical energy can be put in performing the various duties required of it, for the benefit of the local farming community, the small country towns surrounded by such farming communities, the lowlands of the State requiring

FIG. 3.



drainage, the mines of the State requiring electrical power, and the interurban roads traversing the State and requiring energy for the propulsion of their cars. If time will permit, I propose to endeavor to show you that the true economic method of the production and distribution of energy for all these purposes,

and for some other purposes to which I will incidentally refer, necessarily involves, so far as a State-wide service is concerned, concentration of production, concentration of distribution, and, if you may choose to call it so, monopoly of administration of the business of producing and distributing electrical energy.

Just by way of introduction, I will throw a few slides on the screen. Fig. 1 gives some estimates of the amount of energy required for New York, and possibly an area within twenty or thirty miles around, from which you will see that at the present time it takes about 678,000 kilowatts to take care of that area.

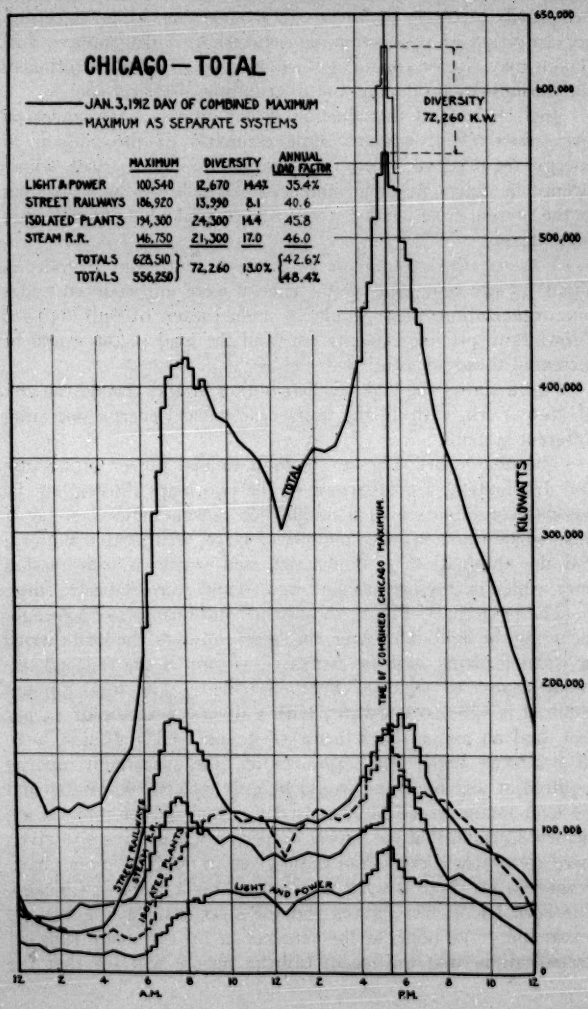
You see, the load factor is 36.9 per cent.; the diversity is about 7.5 per cent., and if this energy were all produced under one organization, there would be a maximum of only 630,000 kilowatts to provide capacity for, and the load factor would be increased to 40 per cent.

Fig. 2 shows the general distribution in and around the city of New York, with all the users of electrical energy operating different systems.

The next chart, Fig. 3, shows a unified power production and distribution, a comparison of the two maps illustrating the possible consolidation of a number of power stations, some of them small, into a reduced number of large, well-located stations, and the elimination of duplication and waste in transmission lines, which in the former chart crossed and recrossed each other.

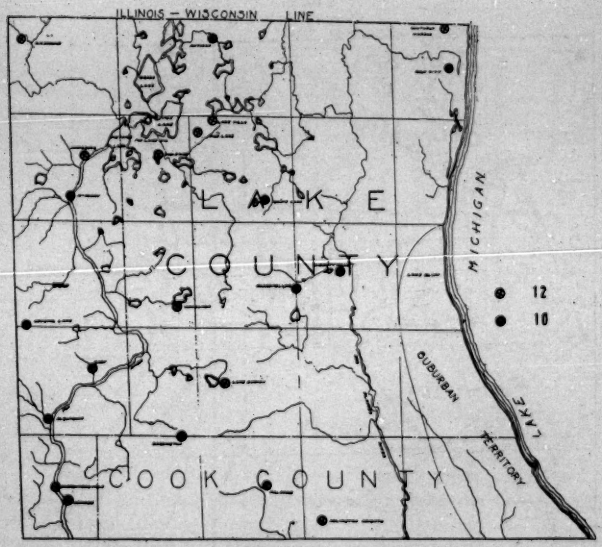
The next chart, Fig. 4, shows the total business of Chicago, including the light and power, the street railways, the load carried by isolated plants, and the estimated amount if the railroad terminal system of Chicago were electrified. The total amount required is 628,000 kilowatts, with a diversity factor of 13 per cent. and an annual load factor of 42 per cent. If that were all produced under one organization, the maximum amount required at any one time would be only 556,000 kilowatts and the load factor would be increased to about 48 per cent. I am inclined to think that the figures on percentage of diversity given there are nearer correct than those given in the New York chart. What you see there is what we are working toward in Chicago. The light and power figures and the street railway figures are a year old. We hope, as the time comes on for steam railroad electrification, that the steam railway people will see that the

FIG. 4.


CHICAGO—TOTAL
JAN. 3, 1912 DAY OF COMBINED MAXIMUM
MAXIMUM AS SEPARATE SYSTEMS
DIVERSITY 72,260 K.W.
MAXIMUM DIVERSITY ANNUAL LOAD FACTOR
LIGHT & POWER 100,540 12,670 14.4% 35.4%
STREET RAILWAYS 186,920 13,990 8.1 40.6
ISOLATED PLANTS 134,300 24,300 14.4 45.8
STEAM R.R. 146,750 21,300 17.0 46.0
TOTALS 628,510 72,260 13.0% 42.6%
TOTALS 556,250 48.4%
650,000
600,000
500,000
400,000
300,000
200,000
100,000
0
KILOWATTS
TOTAL
TIME OF COMBINED CHICAGO MAXIMUM
STREET RAILWAYS
ISOLATED PLANTS
LIGHT AND POWER
12 2 4 6 8 10 12 2 4 6 8 10 12
A.M. P.M.

business of manufacturing energy is altogether a different proposition from the business of managing and operating transportation companies, and the old adage that the "shoemaker should stick to his last" is not a bad maxim for steam railroad men and electrical men to follow.

FIG. 5.

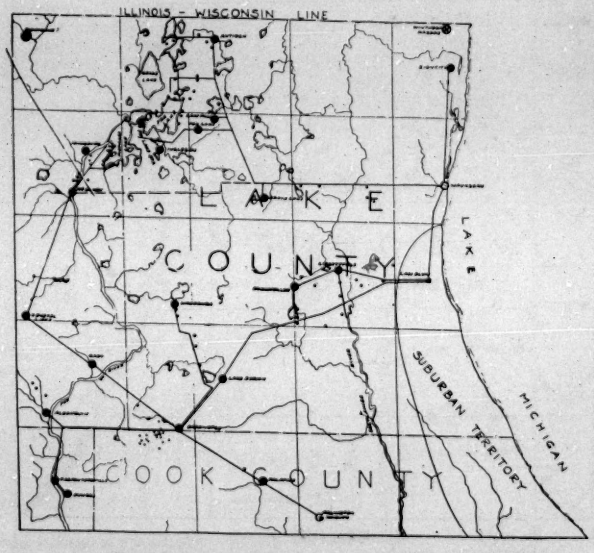


I now come to the main part of my lecture. The reason I have chosen the Lake County district and surrounding territory, shown in Fig. 5, which is the extreme northern corner of Illinois, facing on Lake Michigan, is that this probably is the poorest territory for the purpose of central station distribution that it has been my fortune to operate in. The plants were acquired in that territory in the year 1910.

The towns marked by a crossed circle are twelve in number, with a population of 7886. Those marked by a black circle are the only towns in the territory which had electric service, and that at night only.

The next chart, Fig. 6, shows the condition two years later, in 1912. There are only two places in the county without elec-

FIG. 6.



● TOWNS OF OVER 300 POPULATION WITHOUT ELECTRIC SERVICE, 2, POPULATION 993.
● TOWNS OF OVER 300 POPULATION WITH 24-HOUR ELECTRIC SERVICE, 20, POPULATION 22,188.
· CUSTOMERS OUTSIDE OF TOWNS WITH 24-HOUR ELECTRIC SERVICE, 125.

tric service. There are twenty towns served, having a population of 22,188 people, and there are 125 customers, which are mostly farmers, outside the corporate limits of any of the villages in that territory.

Fig. 7 shows the distribution system, outside of one of the villages, which serves a number of farms. Some two years ago,

when that territory was taken over, an isolated plant was acquired which a gentleman farmer who had a very large farm in this vicinity had installed and which supplied a few of his neighbor farmers in addition to his own requirements, forming the nucleus of the rapidly-developing load of this territory. The main circuit is installed on the same poles with the transmission lines.

FIG. 7.

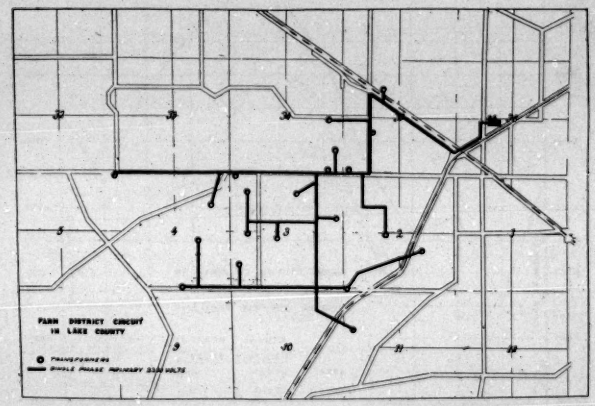
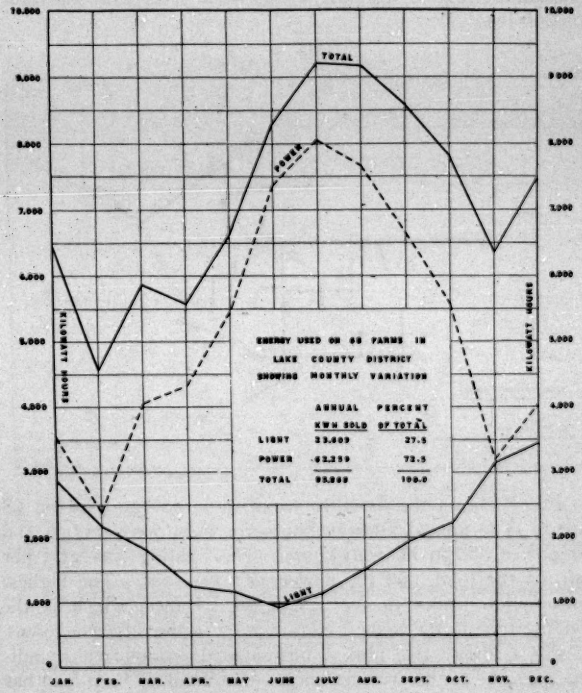


Fig. 8 shows the monthly variation in energy used on 68 farms. The annual kilowatt-hours for light were 23,609 and for power 62,259 kilowatt-hours. The lighting was 27.5 per cent. of the total, and the power 72.5 per cent. The highest consumption comes in the middle of summer, which is the opposite time to the highest consumption in the adjacent towns.

Fig. 9 shows two typical farm-load diagrams, which indicate the same as the previous chart—that rural or farm load has its maximum in summer; they are plotted from actual readings taken at the sub-station. The maximum occurred on the day before the Fourth of July, and the unusually high evening lighting peak is explained by assuming that the city people came out the evening before to spend the Fourth at their country places.

While these curves may not be entirely representative of general farming load, because there are several large farms owned by wealthy city people whose freer use of electricity probably influences the total, nevertheless they include a large number

FIG. 8.



of average size farms and farmers of average means. The curves are probably an indication of the development that is possible for this class of business.

Table I gives some actual statistics on these same 68 farms. The figure of 2.4 horsepower for motors connected is very low indeed, and should eventually increase several times as this business is developed.

TABLE I.

DATA ON LAKE COUNTY FARMS.

Total number of farms	68
Average acres per farm	162

	Per farm.	Per acre.
Incandescent lamps in 50-watt equivalent	30.5	..
Motors in horsepower	2.4	..
Total connected load in kilowatts	3.3	..
Annual light kilowatt-hours	347	2.14
Annual power kilowatt-hours	916	5.65
Total kilowatt-hours	1263	7.79
Income from light	$41.60	26c
Income from power	55.90	34
Total income	$97.50	60c

TABLE II.

COMPARISON OF COST OF ENERGY.

Lake County District.

Investment per kilowatt of maximum	1910	1912
Generating station	$178	$122
Sub-station	..	70
Transmission	..	190
Total	$178	$382
Fixed charge on investment per kilowatt of maximum	$20.85	$42.60
Maximum kilowatts	573	963
Load factor	14.6 %	28.9 %
Costs per kilowatt-hour at local plant or sub-station		
Fuel	2.04c	.61c
Other operating, including sub-station and transmission	3.42	.56
Fixed charges on investment	1.62	1.68
Total costs	7.08c	2.85c

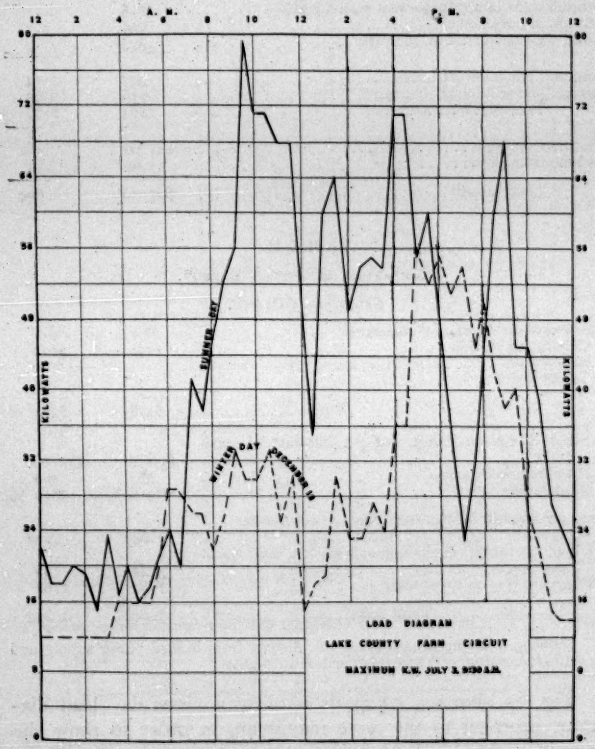
Showing a saving in supplying this district from unified power supply and transmission system of 4.23 cents per kilowatt-hour.

Fig. 10 shows a comparison of two winter-day load diagrams prorated to the same maximum, in order to show the growth of the day load in the Lake County territory and the consequent improvement in the load diagram and load factor as compared with the average local town plant, of which the diagram of 26 towns recently taken over is typical.

I am dwelling at some length on this particular territory

because it is not a manufacturing district and there are very few towns in it, as the suburban district tributary to Chicago, as shown by the map, has been cut out of the figures.

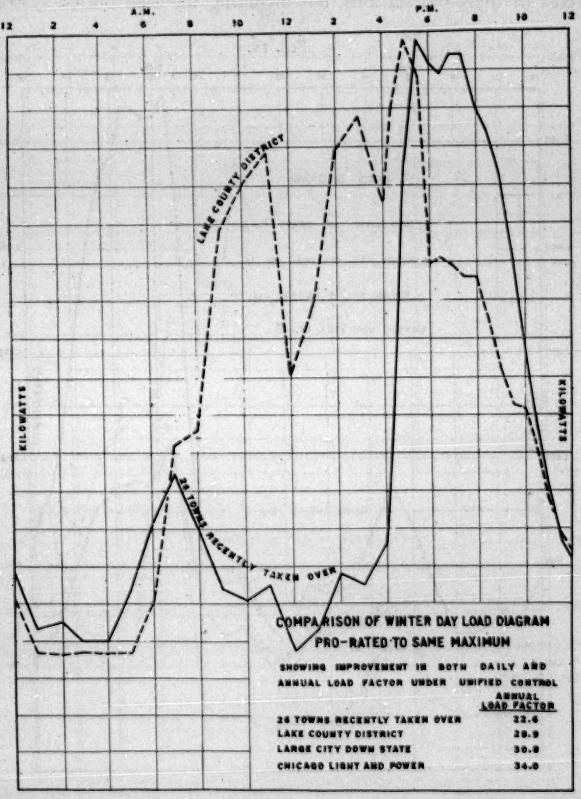
FIG. 9.



The annual load-factor figures show what can be done in the way of improvement by unified control. The annual load factor of 26 towns recently taken over was only 22.6 per cent., while the load factor of the Lake County district, after two years of

unified control, has been brought up to 28.9 per cent., and, for comparison, one of the large cities down the State has a load

FIG. 10.

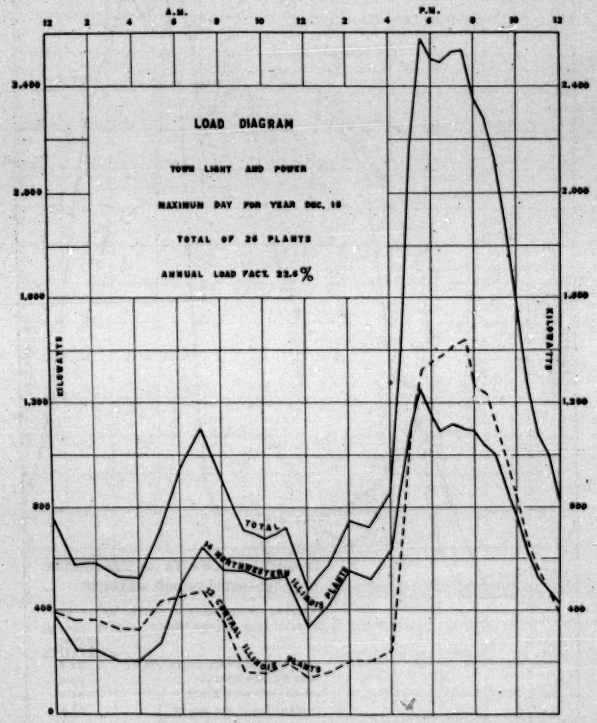

A.M.
P.M.
12 2 4 6 8 10 12 2 4 6 8 10 12
LAKE COUNTY DISTRICT
KILOWATTS
KILOWATTS
26 TOWNS RECENTLY TAKEN OVER
COMPARISON OF WINTER DAY LOAD DIAGRAM
PRO-RATED TO SAME MAXIMUM
SHOWING IMPROVEMENT IN BOTH DAILY AND
ANNUAL LOAD FACTOR UNDER UNIFIED CONTROL
ANNUAL LOAD FACTOR
26 TOWNS RECENTLY TAKEN OVER 22.6
LAKE COUNTY DISTRICT 28.9
LARGE CITY DOWN STATE 30.8
CHICAGO LIGHT AND POWER 34.0

factor of 30.8 per cent., and the Chicago light and power annual load factor, exclusive of railway, is 34 per cent.

Table II gives a comparison of the cost of energy, investment cost, and operating cost under the old plan, when there

were a few isolated central stations in small towns, with the cost of energy for the same territory two years later from a modern station, transmission and sub-station system. The total cost of these old stations, not including the distribution systems

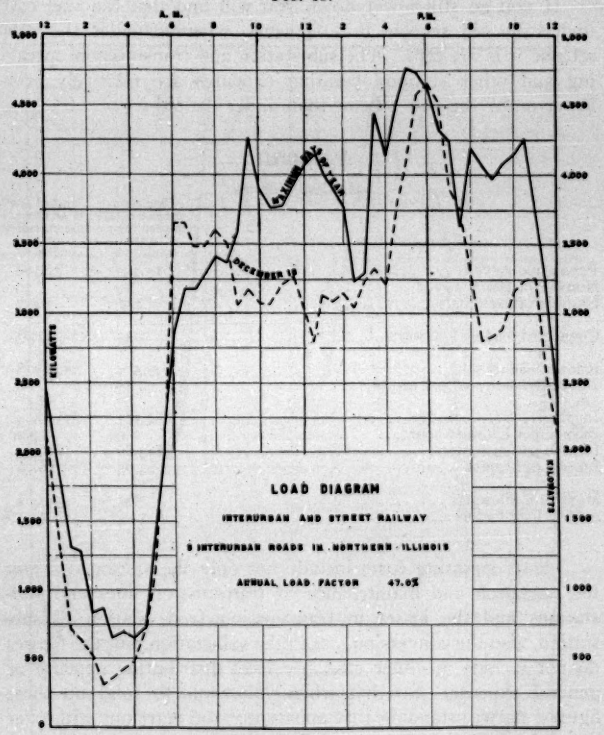
FIG. 11.



used in the towns, was $178 per kilowatt. In abandoning these stations and building transmission lines from a town on Lake Michigan, where we could get cheap energy, and building local sub-stations, you will see the cost was brought up to $382 per kilowatt. Under the old scheme the fixed charges for invest-

ment per kilowatt was $20.85, and under the new scheme two years later the charge was $42.60. These figures would seem to indicate rather a prohibitive proposition, so far as the new

FIG. 12.



scheme of unification is concerned, as compared with small isolated stations. But if you go a little lower down you will see that under the old scheme we had only 14.6 per cent. load factor, whereas with a unified system of power we had 28.9 per cent. load factor.

Applying these respective load factors to the fixed charges on investment you will find that the fixed charge per kilowatt-hour figures out only a mere fraction higher under the new scheme, owing to the great difference in load factor.

If you go still lower down you will find that the fuel cost under the old scheme is 2.04 cents, whereas under the new scheme it is .61 cent. The sub-station and transmission operating and other station operating expenses are relatively even lower under the new scheme than under the old.

TABLE III.

Lake County District.

	Separate management in each town. 1910 conditions	Unified power and transmission system 1912 conditions
Population served	15,395	22,188
Number of towns served	10	20
Number of customers	1,422	3,457
Connected load in killowatts	2,033	4,503
Kilowatt-hours sold	699,574	1,898,978
Kilowatt-hours sold per capita	45	86
Income	$62,371	$136,694
Income per kilowatt-hour	8.9c	7.2c
Income per customer	$43.86	$39.54
Income per capita	$4.05	$6.16
Maximum kilowatts	573	963
Annual load factor	14.6%	28.9%

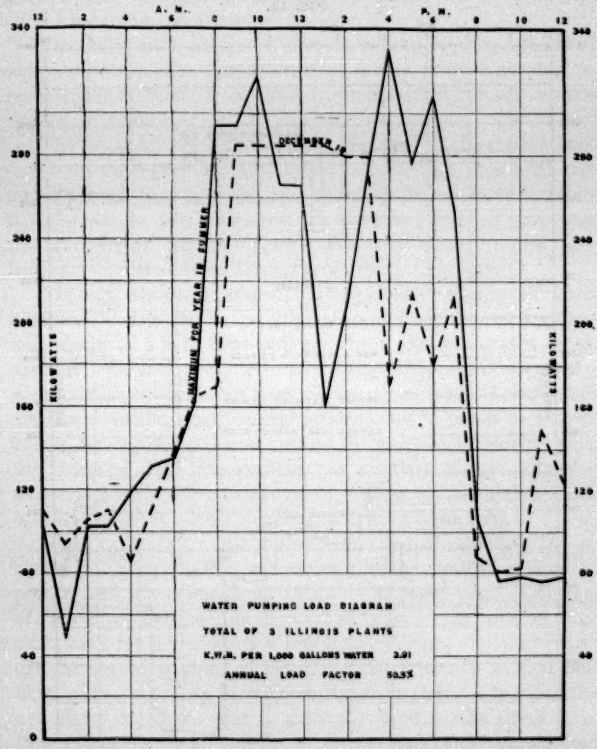
These operating costs include not only the station cost but the operation and maintenance of transmission lines and sub-stations and the losses in transmission from station to sub-station, also the conversion loss in the sub-station, but the figures do not include in either case any local distribution expense or general expense. So that when you come to total up these figures, notwithstanding that apparently you start out with over twice the investment, you will find your base cost per kilowatt-hour at the local lighting plant or sub-station under the old plan was 7.08 cents per kilowatt-hour, and under the new plan 2.85 cents, showing a saving of 4.23 cents per kilowatt-hour.

Table III gives us some further figures on this same Lake County territory.

Fig. 11 is a load diagram showing general light and power for the maximum day.

These are the actual load curves for 26 plants, and it will be

FIG. 13.

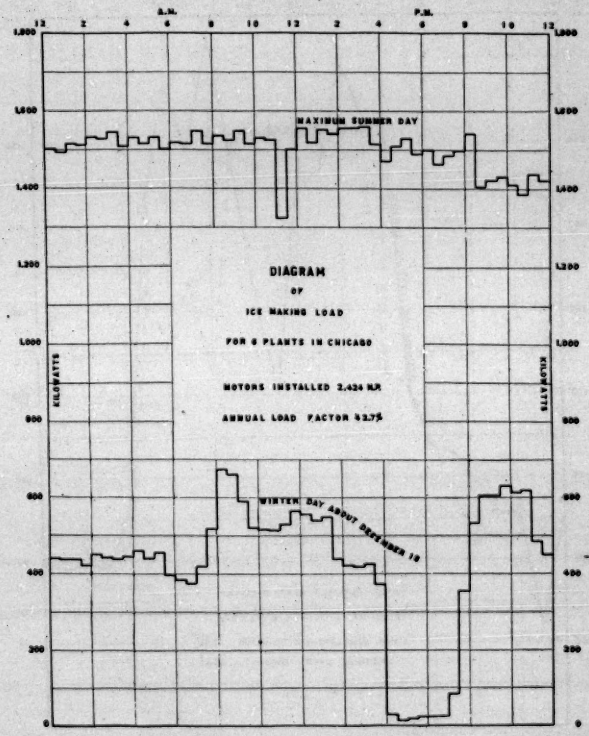


noted that those for northwestern Illinois show a very much better day load than those for central Illinois, probably due to the fact that the northwestern Illinois properties were acquired about a year earlier and the power load has been better devel-

oped. The Lake County diagram still further emphasizes this point.

The total light and power diagram for the State has been prorated from this diagram, and, while this probably gives us

FIG. 14.



the approximate diagram and kilowatt-hour output for the State for this present winter, the improvement in load factor and increase in kilowatt-hour output should be very rapid; that is, we might have estimated the total light and power for the

State based on the Lake County diagram, which would have given a greater output and better load factor and which would probably be a very close estimate to the actual figures.

Fig. 12 is the load diagram of five interurban roads in northern Illinois. The annual load factor is 47 per cent. The maximum load comes on a summer holiday.

The heavy fluctuations of interurban load require, in case of separate power plant for interurban supply only, a greater reserve capacity than if supplied from a station serving several classes of business.

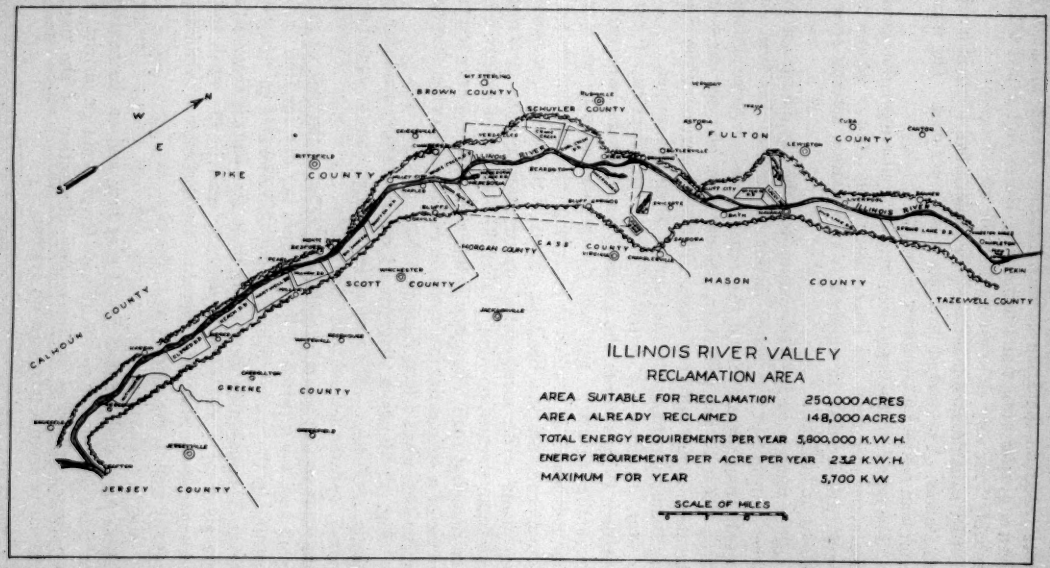
The total kilowatt-hour output for the 62 interurban and street railways in the State, outside of Chicago, has been estimated, from these five and two other roads, on three different bases,—that is, per passenger, per car-mile, and per car,—and the three figure out very close. The total curve for the State has been prorated from these curves using this output.

Fig. 13 shows a water-pumping load diagram of three northern Illinois plants, the kilowatt-hours per thousand gallons amounting to 2.81. You will see the maximum comes in the summer, and it is possible to so arrange this production that it is practically off-peak business. Most of the small water-pumping plants in the small central western towns pump to a reservoir in an elevated position, so that the question of exactly when the pumping shall take place is not a serious matter, except in a case of a serious fire in a town or village. As a rule, that class of business gives a load factor of about 50.5 per cent.

Fig. 14 shows a diagram of an ice-making load for six plants in Chicago. The motors installed amount to 2424 horsepower, and the annual load factor is 42.7 per cent. Contracts are made so that the operations shall cease at the time of maximum load for a period of a few hours per day for four or five months in the winter, which is not objectionable in that business. The reason we have taken these six plants is because they are about of a size that is generally used in the small towns throughout the State, and therefore the load curves would apply equally well to the country as to the city.

Fig. 15 illustrates an entirely different class of business. These maps and the data that I give here and on the next two or three slides refer to the Illinois River drainage district, and we present them as an interesting illustration of the use of electricity from a transmission system.

FIG. 15.


BROWN COUNTY
SCHUYLER COUNTY
FULTON COUNTY
PIKE COUNTY
CASS COUNTY
MORGAN COUNTY
SCOTT COUNTY
MASON COUNTY
TAZEWELL COUNTY
CALHOUN COUNTY
GREENE COUNTY
JERSEY COUNTY
ILLINOIS RIVER VALLEY
RECLAMATION AREA
AREA SUITABLE FOR RECLAMATION 250,000 ACRES
AREA ALREADY RECLAIMED 148,000 ACRES
TOTAL ENERGY REQUIREMENTS PER YEAR 5,800,000 K.W.H.
ENERGY REQUIREMENTS PER ACRE PER YEAR 23.2 K.W.H.
MAXIMUM FOR YEAR 5,700 K.W.
SCALE OF MILES

V. 19

Between the bluff lines, which run approximately parallel to the river, is a wide flat valley which is subject to overflow at times of high water, but when reclaimed by building dikes around suitable areas and draining and pumping out the surplus water, extremely fertile land is made available.

The load factor of the business by itself, being less than 12 per cent., does not warrant the installation of a generating and transmission system for this supply by itself, but when combined with other uses of electricity in the same territory it is valuable business, as it is altogether off-peak.

A cheap power supply should greatly accelerate the reclamation of swamp and overflow land throughout the country.

Fig. 16 shows in detail one section of the preceding map. You will see the lines of the bluffs on either side, and the patches there are the various districts which have already been reclaimed or which it is proposed to reclaim.

The pumping station is always located at the best point in the district to drain all the land and to return the water to the river. It is quite an advantage sometimes to locate more than one pumping station in a district, because of topographical conditions involving quicker and better drainage. This is perfectly practicable with motor drive, while it is usually out of the question to build two steam plants in the same district.

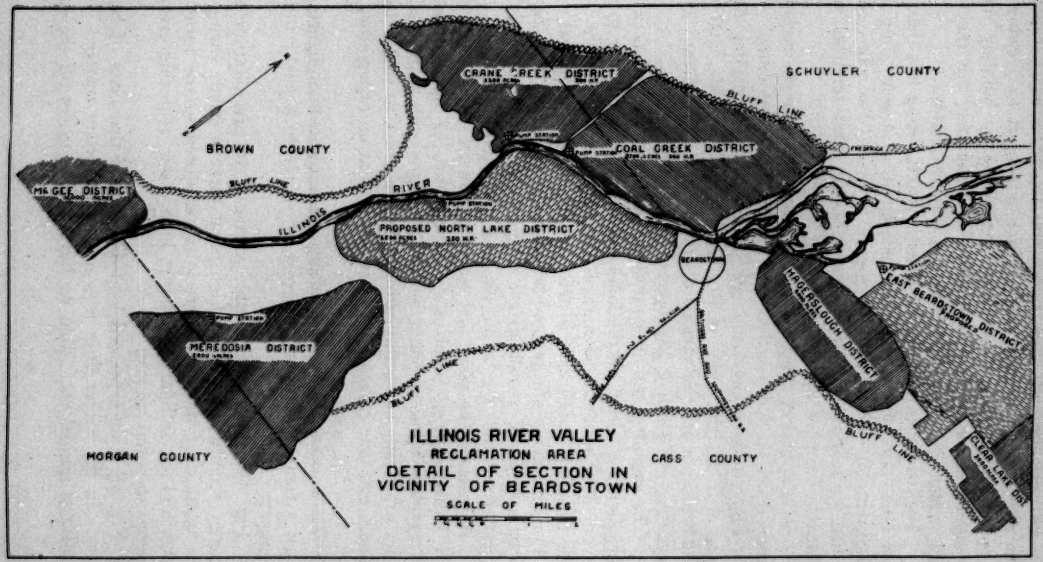
A co-operative plant and transmission, as was planned for the entire district, involves an expenditure of approximately $1,335,000, while a public utility company with transmission lines practically along the entire valley, in order to supply local towns, can take care of this same business at an expenditure of not over $411,000.

The cost of co-operative output per kilowatt-hour figures at least 3 cents higher than the cost of supply to a public utility company.

Fig. 17 shows the monthly variation in precipitation and energy requirements. The high point there is partly owing to the melting of the winter precipitation stored in the form of snow and ice, and partly owing to high water, requiring greater energy to pump against.

Fig. 18 is an estimated load diagram of that class of business. In the winter days it is not an important matter. The contracts are drawn so that we have a right to cut off the sup-

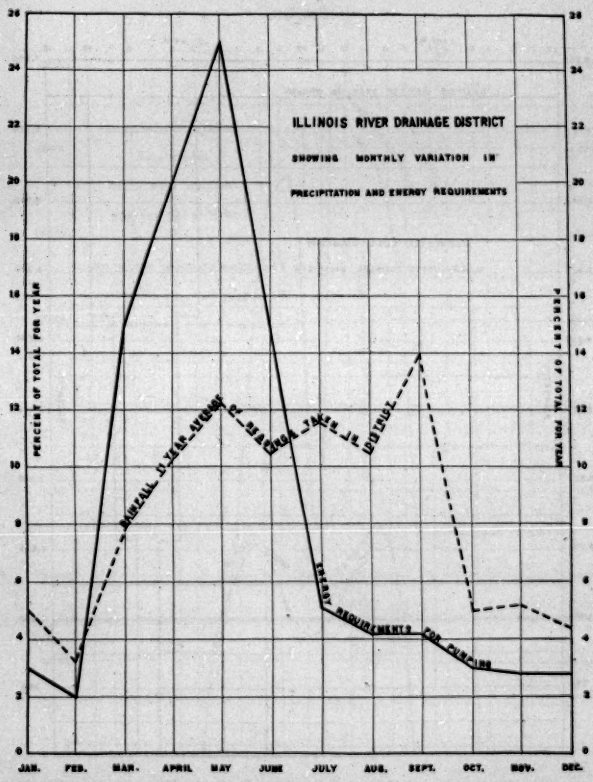
FIG. 16.


CRANE CREEK DISTRICT
SCHUYLER COUNTY
BLUFF LINE
BROWN COUNTY
COAL CREEK DISTRICT
McGEE DISTRICT
BLUFF LINE
RIVER
ILLINOIS
PROPOSED NORTH LAKE DISTRICT
BEARDSTOWN
MEREDOSIA DISTRICT
BLUFF LINE
MORGAN COUNTY
CASS COUNTY
BLUFF LINE
ILLINOIS RIVER VALLEY
RECLAMATION AREA
DETAIL OF SECTION IN
VICINITY OF BEARDSTOWN
SCALE OF MILES

ply for a period of three hours, and consequently it becomes absolutely an off-peak business.

The coal mining load, Fig. 19, has been estimated by mining

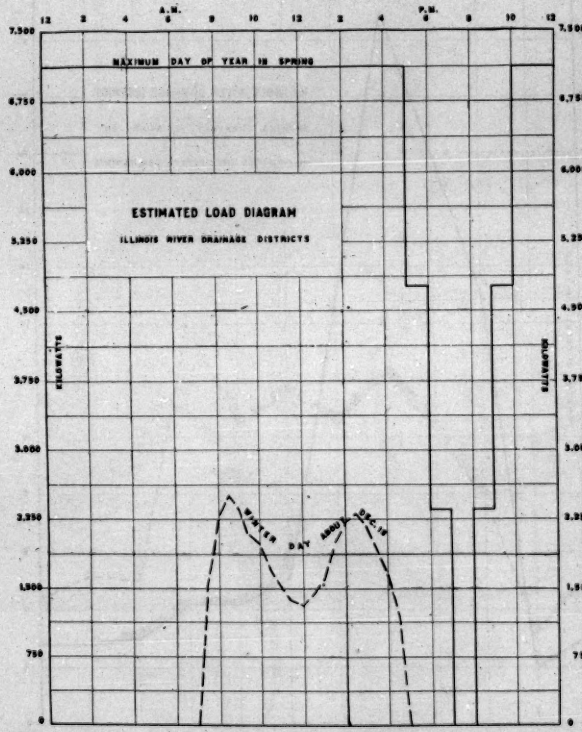
FIG. 17.



engineers from their experience (across the whole State of Illinois) and actual load diagrams of two mines which are operated largely electrically. These data indicate about 1.63

kilowatt-hours at the mine per ton of coal produced, and we applied this figure to the total tonnage of the State, which is approximately 50,000,000 tons, produced by 845 mines. Of these, 586 mines, producing about 5,000,000 tons, are eliminated

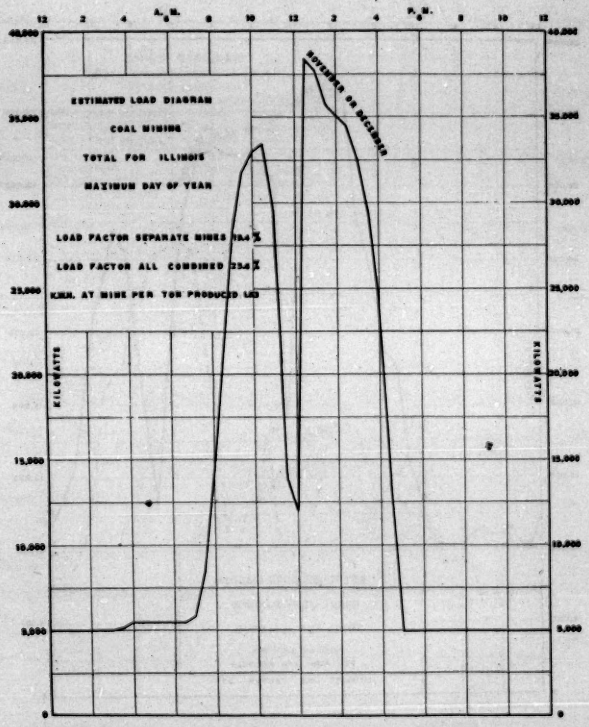
FIG. 18.



as local mines too small to equip electrically. There is added the estimated load for some forty washing and re-screening plants, and then transformer and line losses. The load factor for the individual mines figures about 20 per cent., due to the fact that

the mines are operated only a little over one-half of the number of days per year; but there is considerable diversity between the mines, as one day a mine or group of mines shuts down, and another day some others, so that the load factor for all the

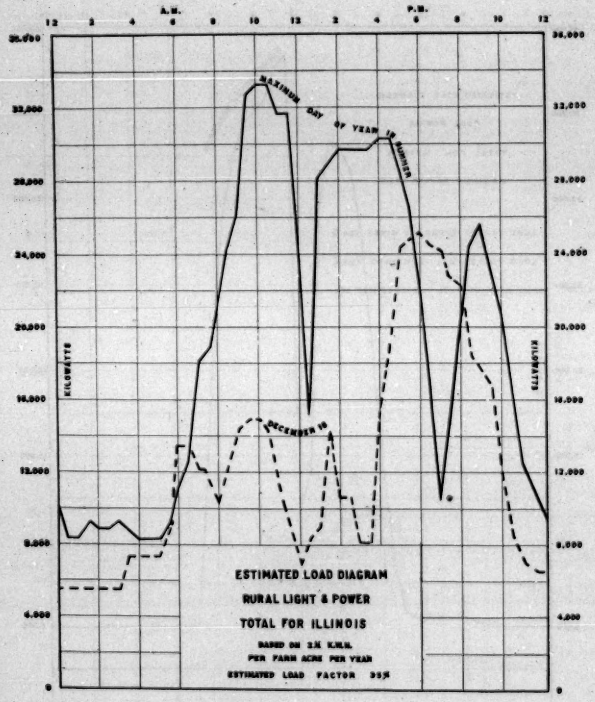
FIG. 19.



mines is brought up to about 25.6 per cent. Further, the diversity is large, as it is practically off-peak business, the men all quitting work at 4 P.M. and being out of the mines before 4.30 P.M., that being earlier than the average evening load for other purposes in the territory.

Fig. 20 shows a load diagram of the total power for rural Illinois based on 2.5 kilowatt-hours per farm acre per year. We have taken the Lake County figures of 7.79 kilowatt-hours per farm acre and cut it two-thirds, so as to be absolutely safe

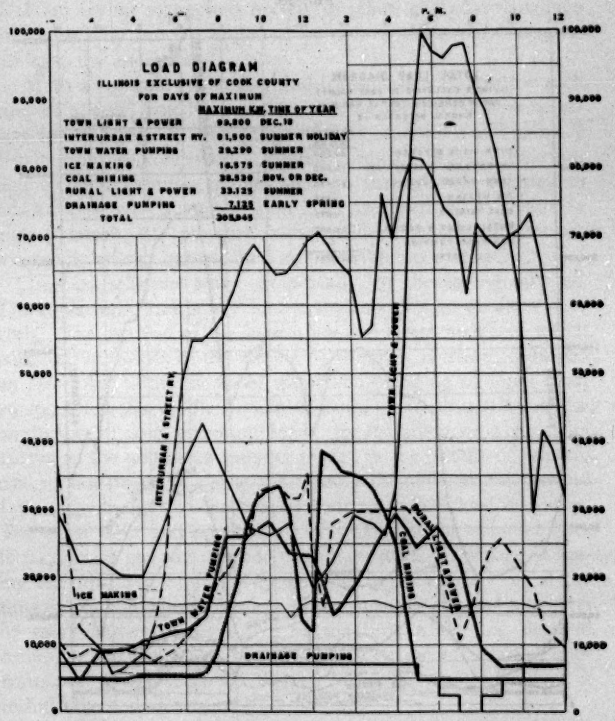
FIG. 20.



in our figuring. The Lake County figures, to my mind—as we had only two years to make any development—are very low indeed, and I believe that the maximum demand for an ordinary farm will greatly exceed in future years 7.79 kilowatt-hours per acre, so that we cannot go very far wrong, so far as minimum

possibilities are concerned, if we take one-third of what we are doing and assume that to be the consumption per farm acre. You will notice the load factor is 35 per cent., and that the maximum, as I told you before, comes in the summer.

FIG. 21.


LOAD DIAGRAM
ILLINOIS EXCLUSIVE OF COOK COUNTY
FOR DAYS OF MAXIMUM
MAXIMUM KW. TIME OF YEAR
TOWN LIGHT & POWER 98,800 DEC. 18
INTERURBAN & STREET RY. 81,500 SUMMER HOLIDAY
TOWN WATER PUMPING 38,290 SUMMER
ICE MAKING 16,575 SUMMER
COAL MINING 36,530 NOV. OR DEC.
RURAL LIGHT & POWER 33,125 SUMMER
DRAINAGE PUMPING 7,125 EARLY SPRING
TOTAL 305,945
P. M.
INTERURBAN & STREET RY.
TOWN LIGHT & POWER
TOWN WATER PUMPING
ICE MAKING
COAL MINING
RURAL LIGHT & POWER
DRAINAGE PUMPING

We now come, Fig. 21, to the marshalling of the figures that have been given in the previous curves. We take the State of Illinois, outside of Cook County and outside of a small suburban district in Lake County, and we find that on the lowest possible estimate the total light and power is 99,800

will probably be electrified first, because they seem to be the simplest to deal with; then will follow the freight terminals, and it will probably be quite a number of years before we get to a point where steam electrification will take place generally. It will probably take place east of the Alleghenies long before it takes place in the Mississippi Valley, because of the density of travel and movement of freight, and owing to density of population, which is so much greater east of the Alleghenies than it is in the Mississippi Valley; but when the time comes, as surely it must come, for the electrification of the great arteries of travel of the country, the economical way for the railroads to get their energy will be to get it from these plants that, in my judgment, will be spread, by that time, all over the States, with

TABLE IV.

SUMMARY FOR YEAR.

	K. W. H.		Maximum K. W.				
					Diversity		
	Amount	Per cent. of total	For year	5.30 P.M. Dec. 18	Amount	Per cent.	Load factor
Light and power	238,717,500	24.9	99,800	99,800	....	..	27.3%
Interurban and street railway	334,996,600	34.8	81,500	78,460	3,040	..	47.0
Water pumping	129,562,500	13.4	29,290	17,430	11,860	..	50.6
Ice-making	62,126,300	6.5	16,575	245	16,330	..	42.7
Coal mining	86,571,500	9.0	38,530	4,975	33,555	..	25.6
Drainage pumping	7,250,000	0.8	7,125	....	7,125	..	11.6
Farming	101,562,500	10.6	33,125	24,990	8,135	..	35.0
Totals	960,786,900	100.0	305,945	225,900	80,045	35.4	35.9%

Load factor of combined systems 48.7%

their transmission lines gridironing the various States and carrying cheap energy to the smallest possible community, thus changing entirely the basis of living, and giving less reason for great accumulations of population for manufacturing purposes in given centres because of the incentive of cheap power, which will not be confined to those centres, but will be available equally in small communities and in large communities. I very much doubt whether the conditions of load shown in the last two charts would be changed if all the steam railroads in Illinois were run electrically, except that the condition of diversity would probably be increased, and consequently the condition of operation would probably be improved and the cost of energy would be reduced, even beyond any figures I can show you to-night.

Table IV sums up in figures what you have seen on the previous curves. It would seem to indicate—and I am rather inclined to think it is a low estimate—that the total amount of

energy that could be disposed of at this time for the purpose of light and power, interurban street railways, water pumping, ice-making, coal mining, drainage, and general farm purposes in the State of Illinois, outside of Chicago, is about 960,000,000 kilowatt-hours, or about one-fifth greater than the present output of the city of Chicago. The maximum load would be 225,000 kilowatts combined, as against 305,000 with them separated, or slightly less than the Chicago maximum.

The last column shows you the load factor of all these businesses separately. The combined load factor of the entire system is 48.7, which is better than is obtained, so far as I am aware,

TABLE V.

LARGE RESERVE CAPACITY.

In Local Plants.

	North-eastern Illinois	North-western Illinois	Central Illinois	Total
Number of towns for which information is available	6	16	47	69
Population	6,885	34,459	141,376	182,720
Maximum	415	1,897	5,898	8,210
Capacity	475	3,385	10,779	14,639
Per cent. reserve	14.5	78.5	82.9	78.4

in any large centre of population in the world, and with an amount of output which, as I have stated, exceeds by one-fifth the largest output, so far as I am aware, in any large centre of population in the world.

Table V shows the reserve capacities, etc. I have had these figures prepared to show you the enormous reserve that small plants, as a rule, carry in Illinois. In northwestern Illinois they have 78.5 per cent. reserve; in central Illinois they have 82.9 per cent. reserve, or with 69 towns and 182,000 population and a maximum demand of 8210 kilowatts they have a capacity of 14,600 kilowatts, being a reserve of 78 per cent.; and yet the service under these circumstances is, as most of you know, very unreliable in small towns.

Table VI shows the estimated saving in plant investment. I have had this statement prepared, which I will refer to in a moment, giving a comparison of the generating plant cost for separate plants and for unified systems. The saving shown

cannot be made except for new or additional business, and as the old plants are displaced on account of wearing out. However, with the rapid growth of all these classes of business, this investment saving can be made in a few years, in addition to an enormous operating saving.

We are assuming that these plants with an estimated capacity of 437,530 kilowatts are put in as separate plants, costing $43,753,000.

TABLE VI.

ESTIMATED SAVING IN PLANT INVESTMENT.

	Maximum K.W. as separate systems	Estimated percentage reserve	Estimated capacity
Light and power	99,800	50%	149,700 K.W.
Interurban and street railway	81,500	40	114,100
Water pumping	29,290	50	43,940
Ice-making	16,575	30	21,550
Coal mining	38,530	50	57,800
Drainage pumping	7,125	50	10,690
Farming	35,125	20	39,750
Totals	305,945	43%	437,530 K.W.

Estimated capacity 437,530 kilowatts at $100 per kilowatt		$43,753,000
Maximum kilowatts for above as combined system	225,900 K.W.	
Plus 20 per cent. reserve capacity	45,180	
Total estimated capacity for combined system	271,080 K.W.	
Estimated capacity 271,080 kilowatts at $75 per kilowatt		$20,331,000
Estimated saving		$23,422,000

The maximum kilowatts for the combined system would be 225,900; with 20 per cent. reserve capacity, which is ample, the total capacity is 271,080 kilowatts, which at $75 per kilowatt is $20,331,000, showing an estimated saving of $23,422,000.

These figures are somewhat misleading to begin with. You could not handle that amount of business in the State of Illinois in small plants at $100 per kilowatt. The operating expenses of those small plants would be so great that it would be impossible to quote a price that would enable you to get the business, so that in a way you would say that would be an impossibility; it would be impossible to raise the money because you would be quite unable to make a showing with a series of separate plants. I do not know how many plants there would be, but they would run up into the hundreds. The only way to give cheap energy to a large rural community, whether it be to the manu-

facturing interests in those communities or for the necessities of the people, such as ice-making, or for mining of coal, or for the performance of public functions, such as water supply, the only possible way that it can be carried out is by concentrated production, which would call for the investment of $20,331,000 in stations.

To go into the matter of operating saving from that class of combination is almost beside the question, as that business can only be secured by a unified system of production having low investment cost in proportion to the load factor, and low operating cost in proportion to the load factor. To try to compare that with the costs of a lot of little local plants, worthless in themselves except for supplying a few lines in their own various communities, would not be of any particular advantage to us in looking into this subject, because the figures I would have to show would be, in a way, misleading, as I would have to assume that it would be possible to get the class and amount of business with the operation of small isolated plants that can only be obtained by a unified system of production.

The figures I have presented you show absolutely that the business in which I am engaged can be run only as a monopoly—successfully run, I should say, as a monopoly. To use the taxpayers' money in putting in a small lighting plant—in using the word "small" I speak relatively, meaning "small" as applied to towns with a population of 500 to 1000, and small as applied to a city of possibly one million or two million population, for what is small in one place would be relatively large in another place; but they are all equally small in total business obtained in any given centre of population—to put the taxpayers' money into that class of investment, whether it is in a little Illinois village or a large city in New Jersey or New York, is simply a waste of money, and, while I do not wish to enter into a discussion of any controversial character in an assemblage of this kind, I do not know of any greater argument against the municipalization of the production of energy than the study of the economics of the business in which I am engaged. A study of such figures as those I have thrown on the screen must lead any man of ordinary intelligence, not necessarily with technical experience, but any man with ordinary intelligence, to the conclusion that the only possible way to operate the business of energy production

FIG. 23.

ILLINOIS.

Towns over 500 population without electric service.

Number of towns.....	180
Population.....	119,200
Population per town.....	660

and distribution is by operating it as a monopoly in so much of the territory as you may want to serve from one organization. It does not necessarily follow that that organization shall cover the whole of a state or the whole of a county, provided the county is large enough for more than one. It does follow, however, that so far as any particular piece of territory is concerned, whether the energy produced be used for operating urban transportation, such as the surface lines and the underground lines, and the elevated lines in a city like Philadelphia, or a portion of the terminal lines, or the main lines of the steam railroads centering in Philadelphia, or the lighting of your streets or for supplying the thousand-and-one purposes that a community like this requires it for, such production and distribution of energy must, for reasons of economy, be a centralized one, whether such centralization be confined to the city or the county, or possibly covering a large portion of the state.

I have a few more slides which I think will interest you.

Fig. 23 is a map of Illinois showing towns of over 500 population which are without electric service, and in addition there is the rural district that is not served at all.

Fig. 24 is a map of Illinois showing all of the towns which have service from local plants owned and operated by local companies, and which, in a majority of cases, is only a six- or ten-hour service. There are 219 of these towns, of which 19 have a population of less than 500.

Fig. 25 is a map of Illinois showing all the towns in which the electric service is owned and operated by some group utility, which service is being rapidly interconnected with and operated from the most economical available source of supply.

Fig. 26 shows graphically the present electric service of the state of Illinois, exclusive of Cook County, analyzed according to population, showing that portion which has no electric service, that portion which has service from local plants, and that portion of the population which has service from some utility group. It brings out the fact that a little over half of this population is still without service.

Before taking my seat I want to say it would have been impossible for me to prepare any such statistics and curve sheets as I have shown you if I had not had at my command the devoted service of a large staff of statisticians, ably headed by Mr.

FIG. 24.

ILLINOIS.

Towns with electric service under local management.

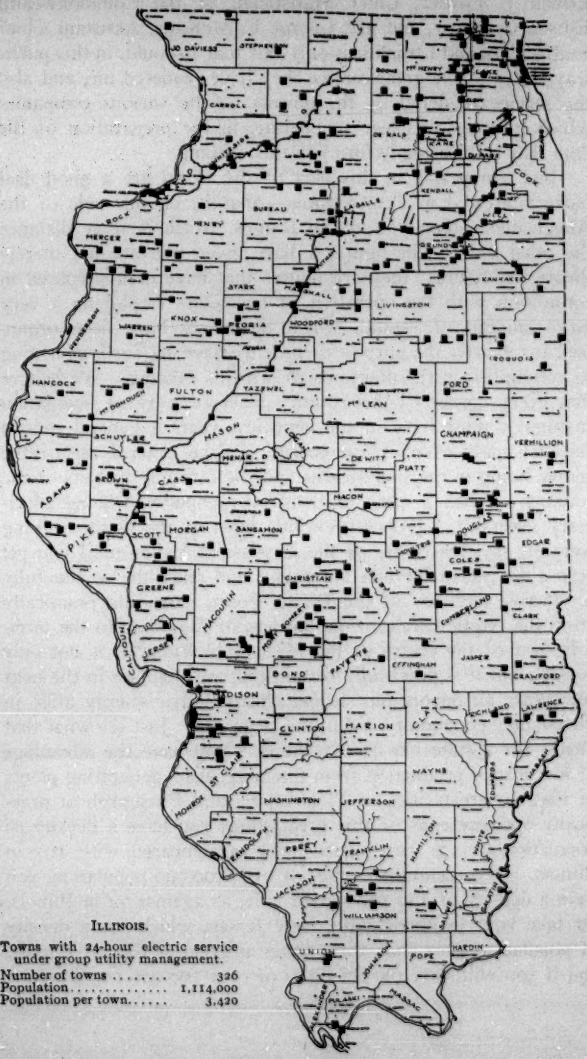
Number of towns	219
Population	452,400
Population per town	2,070

V. 19

Edwin J. Fowler, Chief Statistician of the Commonwealth Edison Company, and Mr. George E. McKana, Assistant Chief Statistician, and I think it is only fair that I should, in this public way, refer to the great service they have rendered me, and also the service rendered by the officers of the various companies which it is my privilege to operate, in the preparation of the data that I am using before you this evening.

But you people in this part of the world are a good deal more interested in Pennsylvania,—that is, on this side of the Alleghenies,—than you are in Illinois, which is some distance the other side. The figures I have given you are not merely theoretical figures; they are figures that have been prepared in connection with the operation of businesses employing a very large amount of capital, which businesses have been organized for exactly the purposes which we have set forth as hoping to accomplish in the diagrams shown this evening. We believe that every corner of this country where density of population justifies it must have in the next few years a general central station supply of electrical energy for the general use of the people living in the small towns and the farming districts of the country. When I speak of density of population being a primary necessity, I probably exclude most of the territory lying west of, say, the centre of the Mississippi Valley until you get across the Sierra Nevada Mountains and reach the wonderfully productive territory of the Pacific Coast, extending practically from the Arctic Circle to the borders of Mexico. In the territory east of the centre of the Mississippi Valley it is not only possible but it is practically certain that we shall see in the next few years an opportunity to get cheap electric energy alike in the country community and in the large city. Just see what that means for a state like Pennsylvania. You have the advantage of low cost of production from the large steam generating plants of the two great cities of Philadelphia and Pittsburgh at practically opposite ends of this great state; you have a density of population of 171 per square mile, as compared with 101 in Illinois. If you eliminate cities of over 100,000 population, you have a density of 122 per square mile, as against 62 in Illinois. Or take your neighbor state, New Jersey, which has a density of population more than three times as great as that of Illinois, and if you will leave out the cities of over 100,000 population it

FIG. 25.



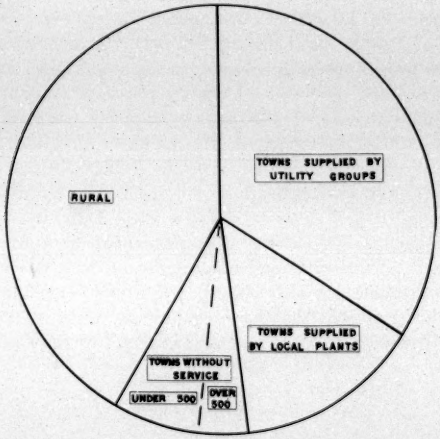
ILLINOIS.

Towns with 24-hour electric service under group utility management.

Number of towns	326
Population	1,114,000
Population per town	3,420

has a density of almost four times that of the state of Illinois. So that what is possible for us on the other side of the Alleghenies is certainly equally possible for you people on the Atlantic seaboard. To come back to Pennsylvania, besides having the advantage of economical production at two ends of the state in very large centres of population, you have probably a million

FIG. 26.



Electric service analysis by population. Illinois, exclusive of Cook County.

	Towns.	Population.	Per cent. of total.
Supplied by utility groups	326	1,114,000	34.2
Supplied by local plants	219	452,400	13.8
Without service: over 500	180	119,200	3.6
Without service: under 500	1,713	210,300	6.5
Rural	...	1,366,100	41.8
Total	2,438	3,268,000	100.0

horsepower in water-power in the state; you have untold wealth in mines, and I cannot see why it should not be cheaper to transport energy the short distance that it would have to be transported to some of the large centres of population in Pennsylvania than to spend the money in transporting coal on the railroad. If it is possible to achieve anything like the cheap production of energy that a general unified system would have to do in the country districts, as comparable with the prices

paid for energy in large centres of population, see what a difference it would mean to our working population. The manufacturer has to go where he can get cheap raw material, where he can call on a large labor market; still, there are many industries which can be developed in the centre of a farming district, where the farming population could be called upon to labor when they are not employed on the land. To my mind there is no more important factor in the great problems of life, the problem of how the workingman can get fresh air, the problem of how he can bring up his family in healthy localities, than the proper solving of the problem of the economical generation and distribution of energy for country districts.

I think it was Lord Macaulay who made the honest statement that "of all inventions, the alphabet and the printing-press alone excepted, those inventions which abridge distance have done most for civilization." Lord Macaulay died before the opening of the electrical energy era. I think if he were living to-day, and if he were penning those lines over again, he would have had in mind amongst the inventions which have abridged distance not only the telegraph and telephone, but he would add inventions that have enabled us to carry energy for the use of men at remote distances, in small towns and country districts.

Microstructure of German Silver. O. F. HUDSON. (*Inst. of Metals*, March, 1913.)—Samples of German silver, containing copper 58.0, nickel 18.5, and zinc 23.5 per cent., annealed under ordinary works conditions for varying lengths of time at 700° C., were polished and etched for micro-examination. A strongly acid solution of ferric chloride was used for etching. The usual crystalline growth on annealing was shown to take place, and the cold-rolled alloy still showed the original cored structure of the cast material, even after 48 hours' annealing at 700° C. After 72 hours' annealing at 700° C. the alloy was practically homogeneous. These observations were confirmed on material prepared in the laboratory and similarly treated. A coarse crystalline structure due to prolonged annealing showed in itself no sign of inferior rolling qualities, all the annealed specimens rolling easily and well. When tested for hardness by the Shore scleroscope no decrease in hardness was observed beyond that due to the normal annealing operation. The paper is illustrated by twelve micro-photographs.

STRESS CONSIDERATIONS IN AËROPLANE DESIGN.*

BY

DR. A. F. ZAHM.

THE United States Navy has initiated the expedient of requiring the prospective fabricator of its aëroplanes to furnish exact estimates showing their adaptation to the purposes and flight conditions specified by the officer in charge of aviation. This requirement serves a two-fold purpose: it stimulates more careful, more adequate design; it discovers and favors those firms capable of producing the best machines. Incidentally it tends to eliminate the incompetent manufacturer from the list of competitors for a most desirable patronage.

The data needed by so careful a purchaser as the Navy are manifold and searching. Besides the general dimensions and capabilities of its prospective flying-machines, it must have their fundamental details. It needs to know the strength and resilience of all the important parts of an aëroplane; the pressure distribution on them at all speeds and attitudes of flight, in both straight and curvilinear movement; the stresses in all parts under various conditions; the position of the centre of gravity, the travel of the centre of pressure, the moment of inertia referred to the axes of the machine; the character of its appliances for controlling the speed, poise, and steadiness of flight; the efficiency of the engine, of the propulsive system, and of the aëroplane as a whole; the possible range of speeds; the running expense; the qualifications for launching and lighting on land and sea.

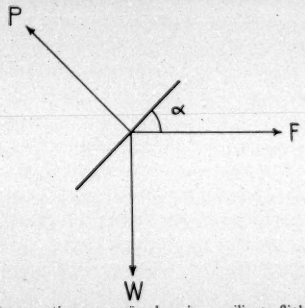
Some part of this information can be obtained directly by calculation from the general dimensions of the aëroplane; but a large portion can be acquired only through experimentation. We may in this article consider some of the questions which can be answered directly by simple analysis.

As an example, suppose that the speed and curvature of path are given for a specified aëroplane in uniform horizontal flight, and that the manufacturer is required to furnish stress diagrams of the main wing-framing for these conditions. He may assume that the machine is banking around a level curve and held to its

* Communicated by the author.

course, as shown in Fig. 1, by three forces: the weight W, the centrifugal force F, and the wing pressure P, which just balances the other two, and can be represented as the diagonal of a rectangle constructed on them as sides. If now he can find the relation of this wing pressure to the weight of the aëroplane, for the given conditions, he may proceed to work out the required stress diagram. But from the force rectangle just mentioned it is obvious that the ratio of P to W is the secant of the angle of the bank, while the tangent of that angle is the ratio of F to W. This latter ratio has the familiar value V^2/gR, in which V is the speed of flight and R is the radius of curvature of the horizontal path.

FIG. 1.



Forces acting upon aëroplane in curvilinear flight.

For the convenience of busy engineers, and for illustrating the stress resulting from speed and curvature of path, we may here produce a table of values of the total pressure perpendicular to the wings, after first deriving the centrifugal force and angle of steady bank for various speeds and curvatures of path. The table will be the more interesting because directly applicable to any car rounding a banked track in running equilibrium,—that is, without tendency to skid to right or left. Taking V as miles an hour, R as feet, and g for simplicity as 22 miles an hour, or 32.1 feet per second, the above expression for the tangent of the angle of bank assumes the easy numerical value $V^2/15R$. By means of this the tangent may be computed for various speeds and curvatures of path; then by use of trigonometric tables

the angle of bank and the secant may be read off. In this manner was formed the following table in which α is the angle of bank; F/W is its tangent; P/W is its secant. The centrifugal force and whole force perpendicular to the wing surface are thus given in percentage of the gross weight of the aëroplane. The table is accurate to the third decimal place, and covers all speeds and curvatures important in the present practice of aëronautical engineering. Obviously the values of F obtain as well also for flight in an oblique or a vertical plane; and, in particular, at the bottom of a swoop the whole normal force P equals F plus the gross weight of the aëroplane; that is, it is found by adding unity to the values given in the columns headed F.

The limiting values in the table, though extreme, are not without interest. They show, for example, that at a speed of twenty miles an hour, or about that of various soaring birds, the normal stress in the wings due to sharp horizontal circling is increased very little,—in fact, only three and one-half per cent. for a radius of curvature of 100 feet. At high speeds, however, such sharp wheeling is unbearable by either the aviator or the machine, if the latter be of ordinarily good construction. Thus at two miles per minute the wind force perpendicular to the wings is multiplied nearly tenfold by rounding a curve of 100-foot radius, and more than doubled on a curve of 500-foot radius. But what happens when an aviator plunges vertically earthward from an altitude of one mile, and acquires a speed alleged to equal 200 miles an hour? For this case the table shows that, if the aëroplane is gradually levelled out, on a curve of 1000-foot radius, the centrifugal force is $2\frac{2}{3}$ times the gross weight of the machine, and hence that the whole force on the wings is $3\frac{2}{3}$ times its gross weight. An aviator weighing 150 pounds would, therefore, press on his seat with a force of 850 pounds. Even so, he would have to begin straightening his machine at an elevation of one thousand feet in order to strike the earth tangentially. Should he begin levelling at a much less altitude, he would suffer sure disaster; for if he curved his path too little he would strike the earth at a considerable angle and at terrific speed, while if he curved enough to avoid this shock he would place an excessive burden upon the framing of his aëroplane and upon his own skeleton.

This last example may be generalized. We may suppose

TABLE I.

Values of the Natural Angle of Bank α Degrees, Centrifugal Force F, and Whole Force P, Perpendicular to the Wings, for an Aëroplane in Steady Circular Flight Round a Level Curve of Radius R, Feet. F, and P, Expressed in Percentage of the Whole Weight W.

Flight Speed	R = 100 Feet			R = 200 Feet			R = 300 Feet			R = 400 Feet			R = 500 Feet			R = 600 Feet			R = 800 Feet			R = 1000 Feet		
Miles per hour	α	F	P	α	F	P	α	F	P	α	F	P	α	F	P	α	F	P	α	F	P	α	F	P
20	14–56	0.267	1.035	7–36	0.133	1.009	5–5	0.089	1.004	3.49	0.067	1.002	3–9	0.053	1.002	2–33	0.044	1.001	1–55	0.033	1.001	1–32	0.027	1.000
30	30–58	0.600	1.166	16–42	0.300	1.044	11–19	0.200	1.020	8–32	0.150	1.011	6–51	0.120	1.007	5–43	0.100	1.005	4–18	0.075	1.003	3–26	0.060	1.002
40	46–51	1.067	1.462	28–4	0.533	1.133	19–34	0.356	1.061	14–56	0.267	1.035	12–3	0.213	1.022	10–5	0.178	1.016	7–36	0.133	1.009	6–5	0.107	1.006
50	59–2	1.667	1.944	39–48	0.833	1.302	29–3	0.556	1.144	22–37	0.417	1.083	18–26	0.333	1.054	15–31	0.278	1.038	11–46	0.208	1.021	9–28	0.167	1.014
60	67–23	2.400	2.600	50–12	1.200	1.562	38–40	0.800	1.281	30–58	0.600	1.166	25–38	0.480	1.109	21–48	0.400	1.077	16–42	0.300	1.044	13–29	0.240	1.028
70	72–59	3.267	3.416	58–31	1.633	1.915	47–26	1.089	1.478	39–14	0.817	1.291	33–9	0.653	1.195	28–34	0.544	1.139	22–13	0.408	1.080	18–5	0.327	1.052
80	76–49	4.267	4.383	64–53	2.133	2.356	54–53	1.422	1.739	46–51	1.067	1.462	40–29	0.853	1.315	35–25	0.711	1.227	28–4	0.533	1.133	23–6	0.427	1.027
90	79–31	5.400	5.492	69–41	2.700	2.879	60–57	1.800	2.059	63–28	1.350	1.680	47–12	1.080	1.472	41–59	0.900	1.345	34–1	0.675	1.206	28–22	0.540	1.136
100	81–28	6.667	6.741	73–18	3.333	3.480	65–46	2.222	2.437	59–2	1.667	1.944	53–8	1.333	1.667	48–1	1.111	1.495	39–48	0–833	1.302	33–41	0.667	1.202
110	82–56	8.067	8.128	76–5	4.033	4.155	69–36	2.689	2.869	63–37	2.017	2.251	58–12	1.613	1.898	53–21	1.344	1.675	45–14	1.008	1.420	38–53	0.807	1.285
120	84–3	9.600	9.652	78–14	4.800	4.903	72–39	3.200	3.353	67–23	2.400	2.600	62–29	1.920	2.165	58–0	1.600	1.887	50–12	1.200	1.562	43–50	0.960	1.386
130	84–56	11.27	11.31	79–56	5.633	5.721	75–5	3.755	3.886	70–27	2.817	2.989	66–4	2.253	2.465	61–58	1.878	2.127	54–37	1.408	1.727	48–25	1.127	1.506
140	85–37	13.07	13.10	81–18	6.533	6.609	77–4	4.356	4.469	72–59	3.267	3.416	69–4	2.613	2.798	65–20	2.178	2.396	58–31	1.633	1.915	52–34	1.307	1.645
150	86–11	15.00	15.03	82–24	7.500	7.566	78–41	5.000	5.099	75–4	3.750	3.881	71–34	3.000	3.162	68–12	2.500	2.693	61–56	1.875	2.125	56–19	1.500	1.803
175	87–12	20.42	20.44	84–24	10.21	10.26	81–38	6.806	6.879	78–55	5.104	5.201	76–14	4.083	4.204	73–37	3.403	3.546	68–36	2.552	2.741	63.54	2.042	2.273
200	87–51	26.67	26.69	85–43	13.33	13.37	83–35	8.889	8.945	81–28	6.667	6.741	79–23	5.333	5.426	77–19	4.444	4.556	73–18	3.33	3.480	69–27	2.667	2.848

the aëroplane, at a given altitude h, to be plunging at speed V, down a slope of ϑ degrees to the horizon, and inquire what centripetal force will compel it to descend in a vertical circle tangent to the earth. From elementary trigonometry one easily finds the radius of curvature of such a tangent circle to be $R = h/\text{versin } \vartheta$ and from a trigonometrical table one derives the following values of $1/\text{versin } \vartheta$ for the angles tabulated:

TABLE II.

Angle of dive	10°	20°	30°	40°	50°	60°	70°	80°	90°
$1/\text{versin } \vartheta$....	65.8	76.6	7.47	4.27	2.80	2.000	1.52	1.21	1.000

Having found from this table the radius of curvature, a glance at Table I will show the force on the wings. For example, if an aëroplane at an altitude of 100 feet dives at an angle of 50° and speed of 60 miles an hour, its easiest volplaning radius of curvature is, from Table II, 280 feet, and hence, from Table I, the centrifugal force F is .96 of the gross weight. This added to the weight itself shows that at the bottom of the swoop the whole force across the wings is nearly doubled. If the assumed altitude had been 50 feet instead of 100, the radius of the circular swoop would have been but half as great, and hence the centrifugal force would have been doubled and the whole force trebled. From these figures it is easy to understand that an aviator, in attempting to startle pedestrians by diving toward them, may suddenly find his easiest circle of recovery too small to follow safely, and himself, therefore, doomed either to strike the earth at a deadly angle of impact, or to overstress his machine in mid-air and to fall with its wreckage.

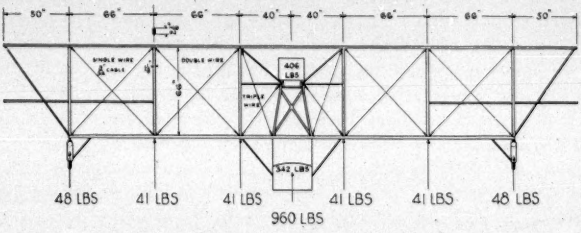
But these remarks on Table I are a digression. The table was prepared as preliminary to finding the stresses in the framing of an aëroplane in curvilinear flight. To simplify this latter task we may assume that when the whole wind force perpendicular to the wings is increased in any proportion the corresponding stresses in the parts of the frame are increased in like proportion. If then we know these stresses for level rectilinear flight, those for level curvilinear flight can be found by multiplying by the proportionate values shown in column P of Table I.

Our first concern, then, is to find the stresses for level rectilinear flight. This may be done either by analysis or by graphical construction. If, for example, the front elevation of the struc-

ture be as shown in Fig. 2, we may suppose the whole wind-lift, which equals the weight, to be uniformly distributed from end to end of the wings, or approximately so, and assume that the upward force exerted on each post equals half the sum of the wind-lifts on the adjacent panels of the sustaining surface, less half the weight of these adjacent panels and their trussing.

Consider, for example, the Curtiss naval hydro-aëroplane of 1912 (Fig. 2), in uniform level flight, and sustained by a wind-lift of five pounds per running inch from tip to tip of its wings. The external arrows in Fig. 3 show the wind-lift exerted upward on the posts, while the internal arrows, bearing values found by analytical statics, show the resulting stresses induced in the framing.[1] One-half of the stay wires are omitted from the sketch

Fig. 2.



Front view of Curtiss naval hydro-aëroplane of 1912.

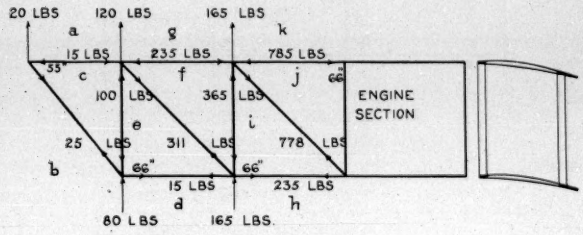
because, under the assumed conditions, these are not stressed unless the wind for an instant strikes the wings on their upper surface. In this case the shown wires would be unstressed and the omitted ones would be stressed very like the ones portrayed in the diagram. This does not indicate that the omitted wires are less severely tried; for when the aëroplane is suddenly arrested in landing they may be subject to instantaneous stresses no less intense than those which the shown wires experience in regular flight under full load.

The foregoing diagrams present the internal stresses computed by the method of analytical statics, as practised familiarly

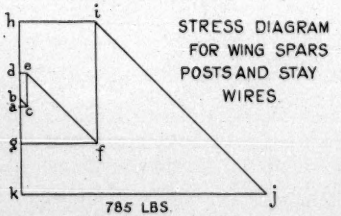
[1] Each of the stresses shown must be divided between the front and rear members, whether wires, posts or spars, probably in nearly equal ratio front and rear.

by bridge engineers. The graphical treatment of the same is given in the lower part of Fig. 3. Both methods, when fully carried out, show the stresses to be very light in the framing of the end panels, much severer in the next ones, and still more intense in the engine section, which is here untreated because of its complexity. When tested by measuring instruments these theoretical forces are found to agree well with the measured

FIG. 3.



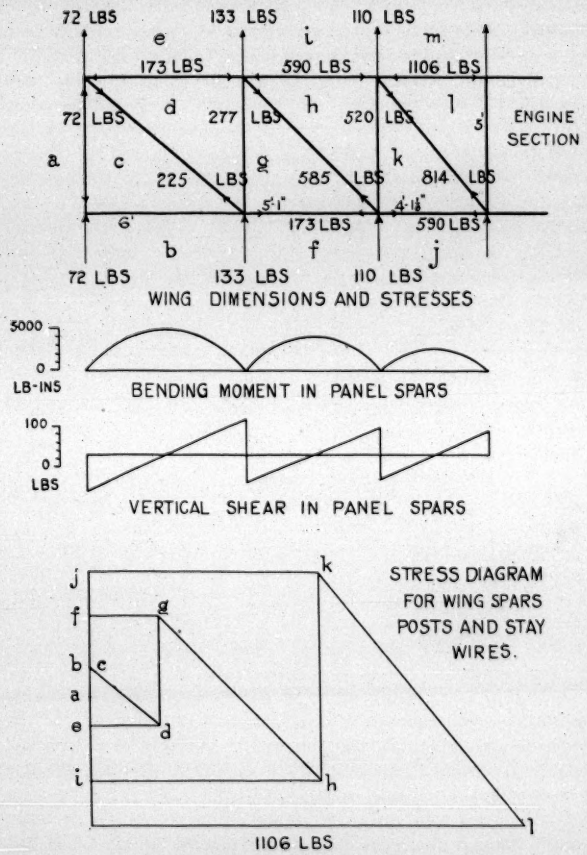
WING DIMENSIONS AND STRESSES.



Analytic and graphic analysis of stresses due to wind-lift in Curtiss naval hydro-aëroplane, 1912.

ones. As a consequence of this combined evidence and of the observed fact that his uniformly wired machine used to break its stays at the inner panels, Mr. Curtiss had adopted the practice of increasing the strength of his aëroplane trussing, step by step, from the wing tips inward to the engine section. Curiously enough, though this gradation of stresses in an aëroplane has been understood by trained engineers since the appearance of the earliest aërial gliders, it has not, even up to the present writing, received due recognition from the generality of aëronautical designers.

FIG. 4.



Analytic and graphic analysis of stresses due to wind-lift in Wright biplane, Model C, 1912.

Figs. 5 and 6 show a like treatment of the forces in a Wright biplane, of model C, for 1912, sustained by a wind-lift of four pounds per running inch. The diagram gives the magnitude of the panels and of the applied forces, assuming the running lift and weight to be practically constant from wing tip to engine section. It also gives the stresses in the framing, assuming the third panel from either end to have but one stay wire—the upper one—in operation. When both the upper and lower wires in the third panels are strained together, their stresses can be computed by a slightly more complicated method involving the theory of elasticity. But by assuming each of the two wires in such panel to operate alone, while its mate is slack or injured, we obtain the major limit of its possible stress in regular flight. The stress in the under wire is about 1.5 times that in the wire above it.

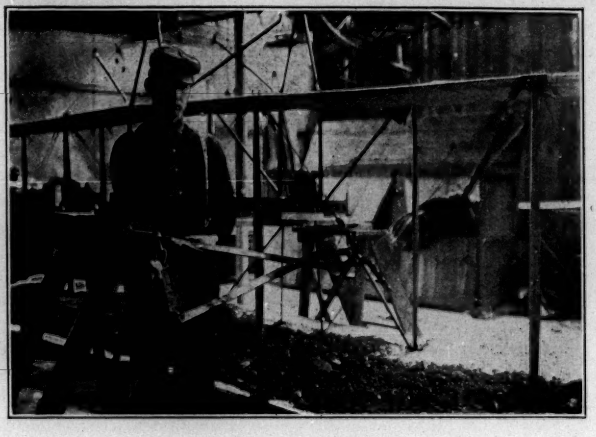
In this aëroplane, as in the Curtiss machine, the stresses are seen to increase rapidly from either wing tip to the engine section. But the design does not show a proportionate increase of strength in the stays and woodwork. If, therefore, the framing of this Wright machine be strong enough at the inner panels it must be overstrong at the outer ones. For want of sufficient data the stresses have not been found for the engine section, nor has account been taken of the stresses due to impact against the earth.

We have now found the frame stresses due to wind-lift for two aëroplanes of well-known types. The method can easily be extended to all other types. To avoid minutiæ, the effect of the individual weight of each post and panel surface has been disregarded; but, since these weights run nearly constant from wing tip to engine section, their effect is merely to diminish in the same proportion all the stresses due to wind-lift. This uniform reduction should be made in more exact estimates.

The stresses due to wind-drift and head resistance can be analyzed in a similar manner. Such analysis discloses a considerable additional tensile stress in the front spars and compressive stress in the rear spars. Combining these with the stresses due to wind-lift previously treated, we find the greatest tensile stress to be in the lower front spar, and the greatest compressive stress in the upper rear spar.

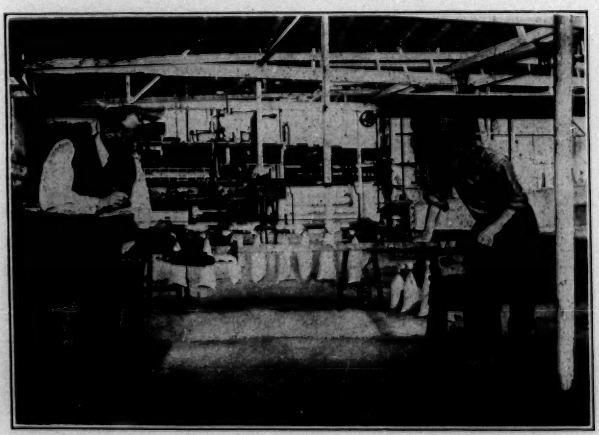
At the suggestion of the writer, Mr. Curtiss has determined

FIG. 5.



Tension tongs applied to measure stresses in aëroplane wires.

FIG. 6.



Apparatus for measuring longitudinal and transverse stresses on aëroplane spar, and deflection caused by them.

experimentally these complex stresses and the strains produced by them. He laid an aëroplane on its back upon a trestle, so placed as to support the middle of its engine section, then loaded its wings with gravel in such manner as to stress their framing approximately as in natural flight. By means of a pair of specially designed tension tongs he now measured the actual stress in each stay wire, and found it to be of the same order of magnitude as that determined for it by analytic and graphic methods.

The tension tongs and the manner of using them are exhibited in Fig. 5. They are like a blacksmith's tongs with jaws slit at their tips to receive and grip the wire at two points an inch or more apart. A spring balance attached to the tips of the tongs handles is made to draw them together far enough just perceptibly to slacken the wire. The tension of the spring is then read and multiplied by the ratio of the length of the handles to that of the jaws. The product is the tension in the stay wire.

The end stress in the posts and spars, though not directly measured by this instrument, is so simply related to the measured stresses as to be estimated directly and with precision. But a more serious question about the spars is the effect of the transverse wind force combined with the endwise thrust, or tension. This effect can be computed by the well-known methods of the theory of elasticity, and has been experimentally tested, in the Curtiss aëroplane factory, by means of improvised apparatus suggested by the writer. A rough analytical estimate may be made here.

To determine analytically the substantial deformation of a spar due to the external forces acting thereon, the spar may be treated as a simple beam uniformly loaded and subjected at the same time to end thrust. Omitting, for the present, the end thrust, the deflection f, at the middle of the panel spar, is given by the formula of applied mechanics, $f = wl^4/77\,EI$, in which w is the running load, l the length of the beam, E the modulus of elasticity of its material, I the moment of inertia of its cross-section. For the Curtiss machine here considered, $w = 5/4$ pound for a single spar, $l = 66$ inches, $E = 15{,}000{,}000$, say, $I = 1/12\ bd^3 = 1/12.\ 1\frac{3}{4}\ (3/2)^3$, in which b is the width of the spar, and d its depth. The formula for the deflection of

the spar at the middle, therefore, gives $f = 0.31$ inch, due to the transverse wind pressure in level rectilinear flight. This bending would not, in the end panels, be materially increased by the lengthwise thrust in the spars; but in the engine section and the adjoining panels the additional deformation due to end thrust may be worth noticing. In normal flight the end thrust is shown by the analytic diagram to be $785/2$ pounds in one spar of the second panel, and, multiplied by 0.31 inch, gives 122 pound-inches as its bending moment, roughly estimated; while the bending moment at the middle, due to the uniform wind-lift on that spar, is about $1/8.\, wl^2 = 1/8.5/4.66^2 = 681$ pound-inches. If the wind-lift be doubled, as by sharp curving, the bending moment and consequent deflection are doubled; and, since the end thrust is also doubled, its bending moment and the consequent deflection are quadrupled: the first moment is therefore approximately 1362, the second roughly 488; the first causes a deflection of 0.62 inch, the second an additional deflection of slightly over 0.2 inch. A like deflection may be found for the Wright biplane and others.

The greatest horizontal unit stress S, in the fibre of the spar in question, due to the wind-lift, may be computed by use of the formula for a uniformly loaded simple beam, $S = Mc/I$, in which M is the bending moment, c the distance from the "neutral" surface to the outer fibre of the spar—being, in the present case, the distance from the centre of the cross-section to the upper or lower part thereof, and equal to ¾ inch. Now, assuming $M = 681$, and I as above, the value of S is found from the formula to be $681.¾.1/12.1¾.(3/2)^3 = 1023$ pounds per square inch, as the unit stress due to that value of M. The moment 122 exerted by the end thrust on the bowed spar induces a further unit stress roughly equal to $122/681 \times 1023$, which, added to the above, makes approximately 1200 pounds per square inch as the stress in the outer fibre due to the whole bending moment here considered. To this must be added the uniform compressive unit stress all over the cross-section of the spar, which is found by dividing the whole end thrust by the area of the section. This equals $785/2 \div 1¾ \times 1½ = 150$ pounds per square inch: and, added to the above 1200, makes practically 1350 pounds per square inch as the unit stress in the outer fibre. This must be somewhat increased in case of the

upper rear spar to include the effect of the drift on the wings in generating end thrusts in the rear spars. Possibly 50 pounds per square inch would be added from this source, if we assume the drift to be about one-eighth of the lift. Thus in level rectilinear flight in still air the unit stress in the upper rear spar of the second panel may equal 1400 pounds per square inch. As this must be greatly increased for the stress in circular flight, in swooping and in passing over "humps" in the air, it appears that the spar ought to be thickened at this part of the wing in order to increase the factor of safety.[2] In passing, it may be noted that $S = Mc/I \propto 1/d^2$, since $c = d/2$, and $I \propto d^3$. Hence, if the spar be doubled in thickness, the stress S is but one-fourth as great.

The experimental method, before referred to, for determining the combined effect of the end thrust and transverse wind force, is shown in the adjoining figure, 6. A horizontal portion of the spar 66 inches long is stressed endwise a chosen amount by the lever and spring-balance, and at the same time transversely loaded with sand bags. By gradually increasing these forces and observing the corresponding deflections, till the elastic limit is reached, the factor of safety for any intermediate stressing may be determined. It is desirable that the stresses in actual flight be measured for a considerable range of conditions.

The means available for determining the stresses in the parts of an aëroplane in actual flight are manifold. If the stay wires sing and by means of some device the pitch of each be observed, or recorded, the stress may be read from a suitable table, or computed from the physical specifications of the wire. The stresses in the adjoining posts and spars are derived at once with certainty by multiplying by a simple numerical factor obvious to every engineer. But, whether the wires sing or not, their tension can be directly measured by one of several methods, as by attaching their ends to a force-measuring lever, or spring, in such manner as not to alter the diagonal distance of the stay-wire terminals. Once having found the stresses in level uniform flight, they may be estimated for accelerated motion, more particularly transverse acceleration, by first recording these sudden

[2] This suggestion from analysis has been adopted in Mr. Curtiss's more recent military biplane, in which furthermore the spars are continuous from engine-section to wing tips.

changes of velocity by means of an accelerograph. If, for example, this instrument shows a transverse acceleration equal to one-half that of gravity at the place of flight, the corresponding increment of stress may be taken as one-half that observed in even flight, disregarding the effect of sudden strain.

The magnitude, direction and position of the wind force on each segment, or panel, of the aëroplane should likewise be determined in uniform level flight. This can be done by the manometric method of determining the pressure at each point of the surface and framing, then summing over the whole to find the resultant force. But a more direct method is to attach the panel, or segment, of the wing to the main part in such manner that it can slide freely up and down and fore and aft, and rotate about a vertical or longitudinal axis. No great difficulty should be experienced in attaching the segment so as to permit these three movements through a very slight distance. If now the forces opposing these three very small displacements be measured in actual flight the resultant wind force is completely determinate.[3] The equations applicable to these three statical conditions will be obvious to the trained engineer.

NOVEMBER, 1912.

Use of Thermit for Obtaining Sound Steel Ingots. H. GOLDSCHMIDT. (*Iron and Steel Inst. Journ.*, lxxxvi, 78.)—The method formerly adopted of pushing a thermit cartridge through the crust and into the pipe of a partially solidified ingot to melt the surrounding metal did not work satisfactorily. Latterly the cartridge has been pushed right down to the bottom of the ingot before solidification commenced. The vigorous reaction set up brings about an energetic agitation of the contents of the mould, expelling the liberated gases and driving the segregate upward. When the reaction has subsided, considerable subsidence of the metal occurs, and fresh metal is poured in from the ladle. The new method has proved very efficient, especially in the case of non-siliconized steel. A saving of 36 cents per ton is effected on the rolled material, which also shows greater uniformity in mechanical properties than untreated steel.

---

[3] This assumes that the lift drift ratio is the same all over the wing segment; otherwise a fourth equation may be needed; and this may be formed by taking moments about two axes instead of one only.

RECENT PROGRESS IN THE STANDARDIZATION OF DISINFECTANTS.*

BY

JOHN MORRIS WEISS,

Member of the Institute.

THE trend of medical science to-day is toward prevention rather than cure. The battle against those microscopic vegetable organisms which are the causative agents of disease is an increasing one. In this battle the true scientist uses, as one of his principal weapons, "*disinfectants*," or, to be more exact, "*bactericides*." The question as to the efficiency of these agents is one which cannot be solved by chemical analysis, but which requires methods, special in their field, to obtain a rational solution. It is the writer's intention to briefly give a *résumé* of the work which has been done in the past toward development of a standard bacteriological method for this purpose, as well as a general survey of the status of disinfectant standardization, both in this country and abroad.

The standardization of disinfectants as to their germicidal power is a matter of no little importance. At present there are many preparations on the market which are practically valueless, and whose use causes a menace of "fancied security" to the public. It is only just that the user of such an article knows exactly what its real efficiency is. This is the primal aim of disinfectant standardization—to protect the public from fraud, to give the layman an opportunity to exercise intelligent selection, to place upon the label of every article sold for germicidal purposes a plain, clear statement of its real value, instead of a multitude of fictitious claims and assertions, few of which could be substantiated by an impartial scientific inquiry.

The writer will pass over the various works published up to 1881. Before that time all experiments on the action of disinfectants had been qualitative. In the year mentioned, Koch[1] put forth the "*thread method*" of testing the relative activity

* Communicated by the author.

of disinfectants. Threads impregnated with anthrax spores were submitted to the action of various dilutions of different disinfectants, thoroughly washed with sterile water to remove the residual disinfectant, and then planted on solid culture media. So far as the writer knows, this method is in no general use at present, having been supplanted by more improved procedures proposed later.

This method was used by various workers for some years, of whom Esmarch,[2] Fraenkel,[3] Henle,[4] Behring,[5] and Geppert[6] may be mentioned. The next method set forward was by Krönig and Paul,[7] and is known as the "*garnet method.*" In this, garnets of a uniform size were sterilized and dipped into a culture of anthrax spores and allowed to dry. These were then placed in the disinfectant, and at various intervals several were removed, gently washed to remove excess of disinfectant, and then placed in a definite amount of sterile water and shaken strongly enough to detach the adherent organisms. A measured quantity of this wash water was then plated in the usual way, and the colonies of bacteria which developed were counted. In the same year Defries[8] proposed a method which essentially consisted of placing a few drops of culture in a tube, allowing it to dry to a film, introducing the disinfectant, and, after the desired time had elapsed, pouring it out, washing, and adding sterile broth. Incubation then showed whether the bacteria had been killed. Neither of these methods is standard to-day, although the former has been quite extensively used by different workers, —Madsen and Nyman,[9] Firth and Macfayden,[10] etc.

The method that has enjoyed the greatest prominence and has come into most general use is the "*drop method,*" as originally proposed by Rideal and Walker[11] in 1903.

The essential feature of this method is the comparison of the strength of disinfectants which kill *B. typhosus* in a definite time under carefully standardized conditions, with the strength of pure phenol solution necessary to accomplish the same results under the same conditions. Four dilutions of the disinfectant under test, and one dilution of phenol, are taken, and a definite amount of *B. typhosus* culture added to a definite amount of the various dilutions under sterile conditions. At various times, in regular order, sub-cultures are made, using a standardized loop, and the results observed after 48 hours' incubation. The quo-

tient obtained by dividing the dilution of disinfectant which kills in a definite time by the dilution of phenol required to perform the same work in the same time is called the "Rideal-Walker coefficient" of the disinfectant. All the variables in the test have been carefully standardized, so that by *close attention to details* concordant results may be obtained by different workers.

This method was variously modified by the authors and others. Somerville and Walker [12, 13, 14] proposed the use of organic matter in the diluent in the test. Their experiments concerned the use of 1 per cent. solution of blood-serum, mucin, peptone, casein, gelatin, blood and starch, and various mixtures of these materials. Chick and Martin [15] suggested the addition of powdered feces in the test. Fowler [16] proposed the use of urine in this work. Blyth [17] used milk as added organic matter in the determination. All these suggestions were reviewed in great detail by Rideal and Orchard.[18]

The addition of organic matter was approved by them, but the kind and amount should be clearly stated in reporting the test. The organic matter used would naturally depend on the use to which the disinfectant was to be put, as suggested by Somerville and Walker.

In 1909 the Lancet Commission [19] proposed several changes in the Rideal-Walker test. *B. coli* was used instead of *B. typhosus,* and MacConkey's bile-salt medium replaced beef broth. The time interval was lengthened, and spoons replaced the loops used for inoculation. For some years the literature of disinfectants was very much filled with controversy regarding the merits of the two methods. The final result was that the original Rideal-Walker method prevailed, and became the standard in England, while the method of the Lancet Commission fell into disuse.

Quite recently a similar controversy has been opened up again in this country. Anderson and McClintic [20] propose what they style the "*Hygienic Laboratory Method,*" to replace the Rideal-Walker method. The principal changes involved are the increase in the number of dilutions of both phenol and disinfectant, the change in strength of the nutrient broth, and the time factor used for comparison of postulant and phenol. Instead of using the 5-minute period, they employ an average of the 2½- and 15-minute periods. They have also introduced the doubtful

expedient of unplugged seeding tubes, this being made necessary by the increasing number of dilutions used. This method has been adopted by the committee of the Laboratory Section of the American Public Health Association,[21] but, aside from this, has not as yet found general acceptance.

More recently the Hygiene Section of the Eighth International Congress of Applied Chemistry appointed an international committee to confer with a committee of the Fifteenth International Congress of Hygiene and Dermography, to decide on a standard method for general international use, but as yet no report is forthcoming.

Walker and Weiss[22] have investigated the purity of the phenol control, and have given a new method to insure this, based on the solidifying point of the phenol used as a standard, which should not be below 40° C.

This is the general historical review of the subject, and the writer would now consider the extent to which standardization of disinfectants has been made official, and the logical effect of such official recognition.

Abroad, disinfectant standardization has reached its highest development in England and her colonies. In Germany, France, and other European countries, so far as the writer has been able to learn, there is no official method for standardization and comparison. Doubtless it is carried on, and various methods are used, but the subject on the Continent does not seem to have received the attention it deserves.

This reminds the writer somewhat of a passage in "Innocents Abroad," by the late Samuel Clemens (Mark Twain). He and his party are landing at a certain port, and before being allowed to enter are fumigated. In speaking of it, he says:

"These miserable outcasts called that fumigating us, and the term was a tame one indeed. They fumigated us to guard themselves against the cholera, though we hailed from no infected port. . . . However, they must keep epidemics away somehow or other, and fumigation is cheaper than soap. They must either wash themselves or fumigate other people. Some of the lower classes had rather die than wash, but the fumigation of strangers causes them no pangs."

That is the way many of us feel about disinfection in general: we know it is a good thing, but like the bother and trouble

applied to the "other fellow" rather than to ourselves. However, seriously speaking, it is most probable that the more enlightened continental countries, which are under a more or less bureaucratic or autocratic government, can regulate the standard of efficiency of disinfectants to the necessary degree without the measures of popular education necessary in the more individualistic society of countries like England and the United States.

In England the Rideal-Walker test is the universal official standard. Among the British authorities using the Rideal-Walker test to control supplies of disinfectants are the War Office, the Admiralty, the Board of Trade, the India Office, the Office of Works, the Metropolitan Asylums Board, and the cities of London, Westminster, Birmingham, Manchester, Nottingham, Edinburgh, etc. This takes no account of private industrial and semi-public concerns, such as laundries and hospitals, which demand that disinfectants, in common with other purchased supplies, undergo a test to show their actual value for the purposes for which they are intended. The public, too, is educated to the point of knowing what disinfection really means, and the charlatan, imitation articles, which rely on an odor as their recommendation, are mostly reserved for the export trade.

Among the English colonial governments using the Rideal-Walker test as a control may be mentioned Cape Colony, Natal, Western Australia, Victoria, Queensland, Madras, Bombay, Mysore, Shanghai, Hong Kong, etc. Many of the colonial railways also use this method of control in purchases of disinfectant supplies. The Federation of South African States put into effect a very novel and original law. All shipments of disinfectants entering the custom house are subjected to a Rideal-Walker test, and all under 5 have to pay a considerable duty (15 per cent.), while those higher than the figure given come in free. The effect of this law is very well brought out in the following extract from the report of the medical officer of health for Cape Colony for the year 1907:

"Samples of disinfectants submitted by agents tendering for contracts to supply Government departments, as well as samples from all consignments of unknown brands of disinfectants passing through the custom, continue to be examined by the Rideal-Walker test in the Public Health Laboratory.

"No table of the various coefficients obtained during the year

is attached to this report, as it was found that some firms were using the published results for the purposes of advertisement.

"The majority of the higher-grade disinfectants have shown a marked rise in the Rideal-Walker coefficient, and from the samples received from the Controller of Customs it would appear that this colony is no longer being made the dumping-ground for worthless, so-called disinfectants, whose only resemblance to germicides consisted in their possessing a strong smell of coal tar, and being able to produce an opaque emulsion when added to water."

This extract shows most clearly that standardization of disinfectants militates against the dishonest manufacturer, to the benefit of the public, and proves that the subject is one well worth serious consideration in this country.

In the United States to-day great interest has been manifested in the question, but so far but one State has taken official cognizance of the subject. This State is Maryland, and the recognition occurs in Regulation No. 2, Labelling of Disinfectants,—State Board of Health, Maryland, revised to May 1, 1911. The portion of interest in this connection reads as follows:

"All disinfectants manufactured or sold in this State must bear a label showing the carbolic acid coefficient or relative germicidal strength of such disinfectants, as compared with pure carbolic acid.

"In determining the relative germicidal value of disinfectants, the application of the Rideal-Walker test to the typhoid bacillus in a 24-hour bouillon culture may be made, and such results will be accepted until further notice.

"The statement of the coefficient should be made as follows:

"Carbolic acid coefficient 0.3, or 1.2, etc., etc.

"This statement may appear on the principal label, or on a supplemental label or sticker."

In the opinion of the writer, every State should have such a law. It should go even further. There should be a national decree compelling the bactericidal efficiency of the articles to be placed upon each package. This would be along the lines of the present Food and Drug Act, or that relating to insecticides and fungicides. Inefficient disinfection is worse than no disinfection at all, and the user should have some real guarantee that the

material he uses is capable of accomplishing the work for which it is designed. In the present state of chemical and bacteriological science there is no excuse for this not being brought about.

Antecedent to proper legal measures, it is necessary that a standardized method be adopted by unbiased authorities for use in the various laboratories throughout the country, in order that the method of determination may be incorporated in the various acts and ordinances covering this subject. This is necessary in order to prevent useless confusion and litigation, with consequential unfair evasions by unscrupulous manufacturers and dealers.

To the writer's mind, the method to be selected should have the following features:

1. Well-defined technique.
2. Uniformity of results.
3. Simplicity.
4. Adaptability.

By well-defined technique is meant that all details of the test be clearly set forth and standardized to such an extent that no latitude is allowed the worker, either in the manipulation of the test or in the interpretation of the results. The writer has had considerable experience in standardizing various tests used in the coal-tar industry in this country. These tests are largely physical in their nature, such as distillation work, extraction work, specific gravities, so-called melting point or fusing point of bitumens, etc. The actual figures obtained in these tests are not as important as their comparative character—a means by which buyer and seller can agree upon specifications for products which are of more or less unknown composition, and which consist of a complex mixture of organic compounds. Here it is very necessary that the methods be such that the ordinary workers can obtain concordant results. It is surprising how slight details can cause marked variations in these proximate analyses, and how factors which would not ordinarily be given more than passing notice cause wide deviations between different operators. Only by working out *all* small details, and determining the effect of each minute factor, is it possible to know just which points demand careful attention, and which may be regarded as negligible influences. Any bacteriological test for the purposes which this

paper discusses must also pass through such a stage of minute investigation, and emerge, fortified at all points against the differing ideas of various workers as to the essential and the negligible features.

The second requirement, of uniformity of results, is a logical sequel to the first. The only further requisite to this end is that the various workers be so well informed of the necessary details of the test that there is no excuse for deviation or error. If such occur it may be directly chargeable to wilful ignorance on the part of one or the other of the workers.

The third account, "simplicity," is also one of prime importance. If possible, the test should be susceptible of being carried out in the ordinary laboratory, with as little inconvenience and additional apparatus as possible, other than the ordinary bacteriological appliances. It should not be a long, tedious operation, or one requiring specialized training. This is necessary if control is to be constant; in other words, we want accomplishment of results with the minimum effort compatible with accurate and serviceable work. Then, too, if the test is not too long and tedious, there is a greater chance of the worker paying strict and careful attention to those details which are so essential to uniformity.

The fourth and last requirement, "adaptability," is designed to enable the knowledge of disinfectant action to be obtained under special conditions which correspond to the conditions under which the disinfectant is to be used. For ordinary general purposes it would be sufficient to know the coefficient of a disinfectant *per se*,—that is, in presence of bacteria alone, without the addition of organic matter. However, a throat specialist desires to know the disinfecting action in the presence of mucus, the surgeon the action in the presence of blood; the army surgeon, in caring for drainage, must know the value in the presence of feces, urine, etc. Accordingly, in these special cases, mucin, serum, urea, etc., should be added in order to determine their effect. The test should be such that the addition of various materials could be made in the diluent without otherwise changing the technique or introducing needless complications.

Such a method adopted, legislation should follow. Opposition to such legal action could only come from those whose interests were threatened, and this would naturally be those who were

selling inefficient disinfectants under false pretences. To-day I believe the public conscience has so developed that such opposition would be given little consideration, once the general public is awakened to the importance of the subject.

As mentioned before, the situation in this country is in the controversial state. The merits of the Rideal-Walker method, and the Hygienic Laboratory method, as proposed by Anderson and McClintic, are undergoing considerable discussion, and the writer feels that it would not be amiss to give here his own opinions and conclusions.

It is far easier to obtain concordant results with the Rideal-Walker method than with the modified method of Anderson and McClintic, and the reason for this is clearly brought out when the count of simplicity is considered.

The writer has had experience with the operation of both methods, and feels that there could be no unbiased critic but would concede at the start that the Hygienic Laboratory method is far more cumbrous, complicated, and involved than is the older method. It may be noticed in the report of the Committee of the Public Health Association (*loc. cit.*) that the inference is made that there were still some considerable discrepancies observed in tests of duplicate samples by different members of the committee. Further work was suggested to determine the cause of the discrepancies. Now, if the members of this committee, who should, supposedly, be the workers *par excellence* in carrying out the method, fail to obtain consistent concordant results, what chance has the "outsider"? It would seem poor policy to indorse a method as a standard, when operators of this high degree of excellence could not consistently check each other's work. The writer feels that this failure is due, in part at least, to the cumbrousness of the Hygienic Laboratory test. English experience has shown that workers *not specially trained* can obtain concordant figures with the Rideal-Walker method.

In carrying out the Rideal-Walker tests there are but five dilutions in all, which means an inoculation only every half minute. This gives ample time for sterilization of the needle, removal of the cotton plugs from the seeding and medication tubes, making the plant, replacing the plugs, setting the tubes back in their places, and taking up a new pair. In the Hygienic Laboratory method, on the other hand, from 10 to 15 dilutions

of phenol and postulant are used, thereby allowing but 10 to 15 seconds for all these operations. As this would be physically impossible, open, broad seeding tubes are used, and during the test these are exposed to organisms from the air for a period of 17½ minutes, at the very least, and usually considerably more. Any bacteriologist knows that under such conditions some contamination is not a chance, but a certainty, unless a special sterile, dust-proof room is provided, and even then the difficulties would be very large.

In the Rideal-Walker method, on the other hand, all tubes are sealed with sterile cotton plugs, except at the actual moment of inoculation or sub-culture, and the danger of contamination is reduced to a minimum.

Even with the open seeding tubes, and only 10 dilutions to handle, the Hygienic Laboratory method requires considerable mechanical practice before the operator can begin to perform all the operations and still accurately preserve the time intervals. This is probably one of the principal reasons for discordance in results by this method, and one which cannot be eliminated so long as open seeding tubes are used.

So far as adaptability is concerned, the two methods are equal as regards the introduction of organic matter in the diluent, for this addition occasions no change in their regular technique.

The simplicity of the Rideal-Walker method should, in the writer's opinion, give it the preference over the later proposal of the Hygienic Laboratory, because this simplicity makes it more universally applicable. With it many more consumers would be able to test their disinfectant supplies in their own laboratories. It would be far more to the interest of the general public if the means of ascertaining the truth were more accessible and easy of attainment.

But whichever method prevails, the writer will feel that real progress has been made, and, after all, the end in this case is of far greater importance than the means. Progress will be slower in one case than in the other, but the adoption of some test is imperative.

Much is to be hoped from the committee recently appointed by the Eighth International Congress of Applied Chemistry, which will co-operate with the committees of the Fifteenth International Congress on Hygiene and Dermography. Unfortun-

ately, this joint committee is not required to report for three or four years,—that is, before the next Congress. The writer hopes that, so far as this country is concerned, this much-needed reform will not be delayed so long. Let us hope that a method, acceptable to all workers in this country, will be chosen for use as a control over the bactericidal efficiency of various preparations and compounds offered for purposes of disinfection.

This accomplished, it will be the duty of true scientific men to spare no effort and waste no opportunity to demonstrate to the public at large the need and use of this subject. If the public is once awakened in this country, legislation will surely follow, and we will compel honesty and real merit in all disinfectants, a subject for a long time a mystery to the layman and to the average physician and health officer, which has been accepted rather on faith than upon knowledge.

It will be an incalculable gain for preventive medical science, for sanitation, and for the health of the public at large. It will do its share toward elimination of disease and suffering, and serve to shield the careful individuals from the ignorant carelessness of others.

REFERENCES.

[1] Koch: *Mittheilungen a. d. Kais. Gesundheitamte*, vol. i, p. 234.
[2] Esmarch: *Centralblatt für Bakt.*, vol. i, part 2, p. 295.
[3] Fraenkel: *Zeit. f. Hygiene*, vol. vi.
[4] Henle: *Archiv f. Hygiene*, vol. vi.
[5] Behring: *Zeit. f. Hygiene*, vol. vi, 1889.
[6] Geppert: *Deutsche med. Wochenschrift*, 1889, p. 789.
[7] Kronig and Paul: *Zeit. f. Hygiene*, vol. xxv.
[8] Defries: *Journ. San Inst.*, vol. xvii, p. 416.
[9] Madsen and Nyman: *Zeit. f. Hygiene*, vol. lvii.
[10] Firth and Macfayden: *Journ. Roy. San. Inst.*, vol. xxvii.
[11] Rideal and Walker: *Journ. Roy. San. Inst.*, vol. xxiv, p. 424.
[12] Somerville and Walker: *San. Record*, Nov. 29, 1906.
[13] Somerville and Walker: *San. Record*, May 9, 1907.
[14] Somerville and Walker: *San. Record*, Mar. 26, 1908.
[15] Chick and Martin: *Journ. Hygiene*, vol. viii, p. 665.
[16] Fowler: *Royal Army Med. Journ.*, vol. vi, p. 6.
[17] Blythe: *Journ. Soc. Chem. Ind.*, vol. xxv, p. 1184.
[18] Rideal and Orchard: *The Medical Officer*, June 26, 1909.
[19] *Lancet*, 1909, pp. 1454, 1516, 1612.
[20] Anderson and McClintic: *Journ. Infect. Dis.*, vol. viii, p. 1.
[21] *Amer. Journ. Public Health*, October, 1912.
[22] Walker and Weiss: JOURNAL OF THE FRANKLIN INSTITUTE, July, 1912.

Number of β-Particles Emitted in the Transformation of Radium. H. G. J. MOSELEY. (*Roy. Soc. Proc., Ser. A,* lxxxvii, 230.)—The recent researches of v. Baeyer, Hahn, and Meitner show that the β-radiation from a substance can generally be resolved by a magnetic field into several distinct groups of approximately homogeneous rays. Danysz has shown that more than 23 such groups are present in the radiation from RaB and RaC. It is, therefore, interesting to know the number of β-particles emitted from each disintegrating atom evolved by these products. Two methods were used for determining this number. In the first the particles were collected in a brass box thick enough to stop them all, and the number deduced from the negative charge acquired by the box. In the second method there was measured the positive charge gained by the active material (the α-particles being absorbed) as the result of the loss of the β-particles. The number of disintegrating atoms was deduced from the α-particle measurements of Rutherford and Geiger. The results show that each atom of RaB and of RaC emits, on disintegration, probably one β-particle, though the measurement gave 1.1 as the average number. Each atom of RaE appears to emit less than one β-particle. The absorption of the β-radiation from the active deposit was studied, measurements being made both of the number of β-particles penetrating the absorbing material and of the ionization they produce. With the help of the data obtained by Geiger and Kovarik the number of β-particles emitted on disintegration by atoms of UrX, ThD, and AcD were estimated at 1, 0.8 and 1.4 respectively. It is deduced that each atom of RaC emits two γ rays on disintegration.

Disadvantages of the New American Standard Copper Specifications. E. A. LEWIS. (*Met. and Chem. Eng.,* x, 540.)—The new standard proposed by the American Society for Testing Materials, although it has met with approval by many American users and manufacturers of copper, is most unsatisfactory as compared with the high-class copper approved by English users and makers. Its lays too great stress on the electrical conductivity test. The cause of this is, probably, the adoption of electrolytic methods of refining on a vast scale in America, producing very pure copper, excellent for wire and brass alloys of high conductivity, but inferior for wearing purposes, and this specification bars tough, arsenical copper, which has valuable properties and distinct uses. A point apparently overlooked by the American committee is that it is impossible to work the non-arsenical oxygen copper they recommend. For electrical work the specification is important, but for copper, for sheets, tubes, rods, etc., it is considered valueless and even misleading. It is suggested that bending tests, opening tests, tensile tests, and limitations in the amount of impurities are required.

RECENT DEVELOPMENTS IN STEAM TURBINES.*

BY

H. T. HERR,

Vice-President and General Manager, The Westinghouse Machine Company.

In Fig. *c*, as has been previously shown for the PV diagram, $q = \frac{xy}{xz}$ for the point y.

On the ϕT diagram, Fig. *d*,

$$\phi_w = \log \frac{T}{493}$$

$$\phi_s = \phi_w + \frac{qL}{T}$$

$$\phi \text{ dry} s = \theta_w + \frac{L}{T}$$

But,

$$ea = \phi_w$$

$$eb = \phi_s = \phi_w + \frac{qL}{T}$$

$$ac = \frac{L}{T}$$

$$\therefore q = \frac{ab}{ac}$$

Not the least merit of the ϕT diagram as a means of graphically representing the cycle of operations in a heat engine is, that it shows the heat taken in and the heat rejected, as well as the work done, and so allows estimates of efficiency to be made by inspection of the diagram itself.

XLII. In steam turbine work the energy of the expanding steam is extracted from its velocity through various stages of its more or less approximate adiabatic expansion.

In Fig. *e* an entropy-temperature diagram is plotted for 1 pound of steam which is expanded adiabatically from the point a with T_1 temperature and P_1 pressure and dryness $q = 1$ to b at T_2 temperature and P_2 pressure.

The available energy or work that can be done by a perfect engine under these conditions is represented on the diagram by the area $a\,b\,c\,d\,a$.

*Concluded from page 530.

From the first equation of thermodynamics—

$$E'' - E' = -W + Q$$

But $a\,b\,c\,d\,a$ is a cyclic process—

$$\therefore E'' - E' = 0$$
$$\therefore W = Q$$
$$W = Q = \text{area } a\,b\,c\,d\,a$$
$$= \text{area } o\,e\,c\,d\,a\,b\,f - \text{area } o\,e\,c\,b\,f = \text{area } o\,e\,c\,d\,a\,b\,f - [\text{area } o\,e\,c\,b'\,f' - \text{aree } b\,b'\,f'\,f]$$
$$H_1 = h_1 + L_1 = \text{area } o\,e\,c\,d\,a\,b\,f$$
$$H_2 = h_2 + L_2 = \text{area } o\,e\,c\,b'\,f'$$
$$(\phi_2 - \phi_1)T_2 = \text{area } b\,b'\,f'\,f$$

$$\therefore W = Q = H_1 - H_2 + (\phi_2 - \phi_1) \text{ in B. T. U. per pound of steam.}$$

FIG. *c*.

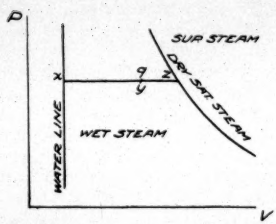
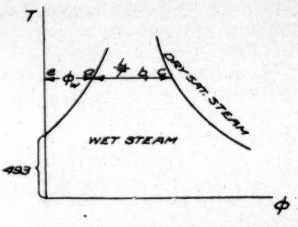


FIG. *d*.



If all this energy could be turned into velocity, the following well-known formula from mechanics for unit mass would give the available velocity of the steam issuing from a suitable nozzle:

$$\frac{V^2}{2g} = W \text{ (foot-pounds)} = Q \text{ (B. T. U.)} \times 778,$$

or, $$V = \sqrt{778 \times 2gQ} = 223.7\sqrt{Q}$$

when V = velocity of the jet in feet per second

g = acceleration due to gravity in feet per second.

Similarly, for adiabatic expansion of steam initially wet or with dryness q as represented in Fig. *f*:

$$W = Q = H_1 - H_2 + (\phi_2 - \phi_1)T_2 - (\phi_1 - \phi_0)(T_1 - T_2)$$

XLIII. The available energy of superheated steam expanding adiabatically between certain ranges of temperature is more difficult of calculation than the two preceding cases of dry saturated

and wet steam. With the aid of the entropy-temperature diagram, formulæ for the three cases of superheated steam may be deduced as follows:

Case I.—When the superheat is just sufficient to bring the adiabatic expansion to the lower temperature of the cycle at the time the steam becomes dry and saturated. Let Fig. *g* represent an ϕT diagram in which $a\,d\,a\,a'\,b'\,b\,c$ represents the work

FIG. *e*.

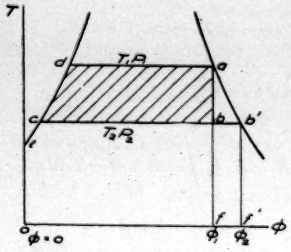
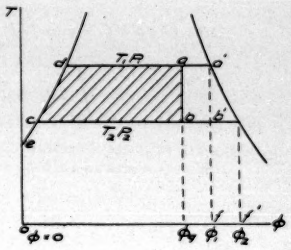


FIG. *f*.



done. The line $a\,a'$ represents the process of superheating from T_1 temperature to T_2 temperature.

From what has preceded—

$$E \doteq E = -W + Q.$$

This being a cyclic process—

$$E'' - E' = 0 \therefore W = Q.$$
$$H_1 = \text{area } o\,e\,c\,d\,a\,b\,f\,o$$
$$H_2 = \text{area } o\,e\,c\,b\,b'\,f'\,o$$

The work done or available energy from the superheat is:

$$\text{area } f\,b\,a\,a'\,b'\,f' - \text{area } f\,b\,b'\,f'.$$

But area $f\,b\,a\,a'\,b'\,f'$ = area under the curve $a\,a'$, which, as has been shown, is equal to $\int T\,d\phi$. (See proof that $\frac{d\phi}{dQ} = \frac{1}{T}$)

$$\therefore Q = \text{area } c\,d\,a\,a'\,b'\,c = H_1 - H_2 + \int_{\phi_2}^{\phi_1} T d\phi$$

Case II.—When the superheat is not sufficient to bring the adiabatic expansion to the lower temperature without the presence of wet steam. Let Fig. *h* represent an ϕT diagram in in which $c\,d\,a\,a'\,b'\,b\,c$ represents the work done.

The line $a\,a'$ represents the process of superheating from T_1 temperature to T_2 temperature.

As before—

$$E'' - E' = 0$$
$$W = Q \text{ (cyclic process)}$$
$$H_1 = \text{area } o\,e\,c\,d\,a\,b\,f\,o$$
$$H_2 = \text{area } o\,e\,c\,b''\,f''\,o$$

The available energy from the superheat is—

$$\text{area } f\,b\,a\,a'\,b'\,f' - \text{area } f\,b\,b'\,f'\ (\phi_2 - \phi_s)\,T_2 = \text{area } f'\,b'\,b''\,f''$$

$$\int_{\phi_s}^{\phi_1} T d\phi = \text{area } f\,b\,a\,a'\,b'\,f'$$

$$\therefore W = Q = \text{area } c\,d\,a\,a'\,b'\,b\,c = H_1 - H_2 + \int_{\phi_s}^{\phi_1} T d\phi + (\phi_2 - \phi_s)\,T_2$$

FIG. g.

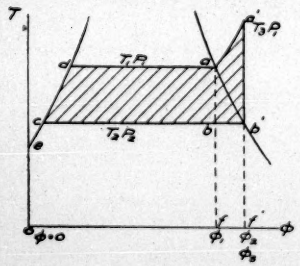
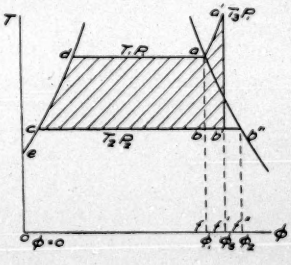


FIG. h.



Case III.—When superheat is still present after adiabatic expansion to the lower temperature at which condensation takes place. Let Fig. *i* represent an ϕT diagram in which $c\,d\,a\,a'\,b'\,b''\,c$ represents the work done, and let the adiabatic expansion from a' to b' bring the steam at temperature $T > T_2$ into the condenser.

As before—

$$E'' - E' = 0$$
$$\therefore W = Q \text{ (cyclic process).}$$
$$H_1 = \text{area } o\,e\,c\,d\,a\,b\,f\,o$$
$$H_2 = \text{area } o\,e\,c\,b''\,f''\,o$$

The available energy from the superheat is area $f\,b\,a\,a'\,b'\,h\,f'\,f$ – area $f\,b\,b''\,h\,f'\,f$ – area $b''\,b'\,h\,(\phi_s - \phi_2)\,T_2$ = area $f''\,b''\,h\,f'$

$$\int_{\phi_s}^{\phi_1} T d\phi = \text{area } f\,b\,a\,a'\,b'\,h\,f'\,f$$

$$\int_{\phi_s}^{\phi_2} T d\phi = \text{area } f''\,b''\,b'\,h\,f'\,f''$$

$$\therefore W = Q = \text{area } c\,d\,a\,a'\,b'\,b''\,b\,c =$$

$$H_1 - H_2 + \int_{\phi_s}^{\phi_1} T d\phi - \int_{\phi_s}^{\phi_2} T d\phi + (\phi_s - \phi_2)\,T_2$$

The five cases for wet, dry saturated, and superheated steam as to the available energy during adiabatic expansion are covered by the following formulæ:

Case I.—Wet steam expanding adiabatically—

$$W = Q = H_1 - H_2 + (\phi_2 - \phi_1)\,T_2 - (\phi_1 - \phi_q)\,(T_1 - T_2)$$

Case II.—Dry saturated steam expanding adiabatically—

$$W = Q = H_1\,H_2 + (\phi_2 - \phi_1)\,T_2$$

Case III.—Superheated steam expanding adiabatically when $\phi_s = \phi_2$—

$$W = Q = H_1\,H_2 + \int_{\phi_s}^{\phi_1} T d\phi$$

Case IV.—Superheated steam expanding adiabatically when $\phi_s < \phi_2$—

$$W = Q = H_1 - H_2 + \int_{\phi_s}^{\phi_1} T d\phi + (\phi_2 - \phi_s)\,T_2$$

Case V.—Superheated steam expanding adiabatically when $\phi_s > \phi_2$—

$$W = Q = H_1 - H_2 + \int_{\phi_s}^{\phi_1} T d\phi - \int_{\phi_c}^{\phi_2} T d\phi + (\phi_s - \phi_2)\,T_2$$

XLIV. The five cases of adiabatic expansion discussed in the preceding section give a cycle of operations, commonly known

as the "Rankine Cycle," which, on a pressure volume diagram, is represented as in Fig. *j*.

A cylinder and piston of perfect non-conducting material are assumed, into which cylinder steam is admitted at an initial pressure P_1 and temperature T_1. This steam is allowed to expand adiabatically until its pressure and temperature are P_2 T_2. On the return stroke of the piston, the steam is exhausted to the condenser at temperature T_2, and after exhaust, and without clearance, steam is again admitted from the source of supply, thus completing the cycle.

By the first law of thermodynamics, the difference between

FIG. *i*.

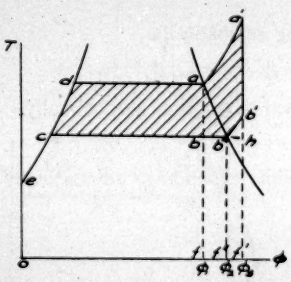
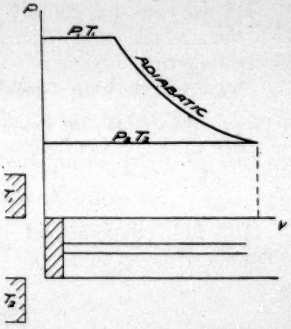


FIG. *j*.



the heat supplied to an engine and the heat rejected is equivalent to the work done, provided there are no losses. It therefore follows that in a steam engine working on Rankine's cycle the heat converted into work is equal to the difference in the heat contents of the steam supplied to and exhausted by the engine. This consideration is used in the discussion of the relative merits of steam turbines as to their efficiency by referring their performance to that of a steam engine using Rankine's cycle, and the efficiency of a turbine is generally stated as a per cent. of that conversion of heat into work that could be obtained if the Rankine cycle were fulfilled.

APPENDIX II.

Designs of Drums and Disks for Rotors of Steam Turbines.

I. DRUM DESIGN.

The general method of procedure is to calculate first the stress in the drum, due to its own mass and velocity, then the additional stress due to the centrifugal force of the blades and their accessory parts, such as packing pieces, lashing, and shrouding.

The stress in a rotating ring of steel, of very small radial thickness, is given by the equation

$$f_t = .106\, v^2 \qquad (1)$$

where f_t = the tangential or "hoop" stress, and v the velocity in feet per second. If the ring has a radial thickness that is not small compared with the radius, this formula does not apply with accuracy. If the radial thickness is not more than one-third the outside radius, a very good approximation may be made by applying the formula (1) with v as the velocity at the mean radius, in which case f_t is to be taken as the mean tangential stress, or the stress at the mean radius; and the stress at any other radius is nearly inversely proportional to that radius. In the case of a thin disk of uniform thickness with radial width .4 of the outside radius, the stress at the inner radius calculated in this way is about 3 per cent. lower than that obtained by the more refined analysis. In the case of the drum the error is somewhat greater, with the assumed radial thickness; but as practically all drums have a radial thickness not more than half that assumed above, the error in such cases due to the above method becomes practically negligible.

The method described, while based on the accepted methods of exact analysis, may be approximately derived as follows: In the disk or drum having a relatively large bore, the radial stresses may be neglected, and hence the radial stretch also; and as all the ideal component hoops or drums of very small thickness thus have the same circumferential stretch, the tan-

gential stress at any radial distance is inversely proportional to the radius.

In determining the drum stress due to the blading, etc., the centrifugal forces of these parts are first found by the well-known formulæ. The total centrifugal load of blades, etc., on any part of the length of the drum when divided by $2\ \pi$ gives the corresponding pull on the cross section of that part of the drum. This pull is further reduced to a mean stress by dividing by the sectional area, and this mean stress is again taken as the actual stress (due to blades) at the mean radius of the drum. The stress at the inner radius is inversely proportional to that radius, as in the case of the unloaded drum. Finally, the total stress at the inner radius is found as the sum of the stresses due to the blade and drum itself.

The effect of the blade loads in stressing the drum as described above is a close approximation, based on the more exact analysis of the drum considered as a "thick tube" with external load.

V.
19

2. DISK DESIGN.

Taking the most general case, that of a disk with a wide rim, the design procedure is as follows: Having determined the necessary section of the rim to suit the blading: First find the mean stress in the rim alone as if it were free from the internal disk, by the method for drums described above. This imaginary stress f_1 is to be reduced by the action of the disk, exerting an inward radial pull on the rim. Assuming that the design of the disk is to be such as to give as nearly as possible uniform stress in both the tangential and radial directions, it is to be noted that the stretch at the outer edge of the disk is but $1 - d$ times that of the rim, where d is Poisson's ratio (about .3 for steel). Hence the hoop stress in the rim is taken at .7 of the uniform stress in the disk. Having decided upon the permissible stress f, the radial pull between the disk and the rim is that corresponding to a mean hoop stress $f_1 - .7\ f$ in the rim, and from this with the given stress f the thickness y_0 required for the disk at its junction with the rim is readily found.

From this thickness as a starting point the design of the disk proper proceeds as follows: If the disk is not to be pierced for

a shaft, the formula of De Laval applies, giving practically uniform stresses.

$$\text{Log}_{10}\frac{Y}{Y_n} = .434\,\frac{K}{2f}\left(r_n^2 - r^2\right) \qquad (2)$$

in which,

Y = thickness of the disk at any radius r.
Y_n = thickness of the disk at the outer radius r_n
f = the permissible stress.
K = the centrifugal force per cubic unit of the material at unit radius at the given angular velocity.

If a disk is pierced with a small hole at the centre, the tangential stress at the bore is double that in the unpierced disk; as the bore is made larger the stress increases still further. It can be shown that it is impossible to design a pierced disk so that the radial and tangential stresses are everywhere equal, as in the disk shaped by the De Laval formula. For the safety of the pierced disks the thickness is generally increased toward the centre at a faster rate than that given by the De Laval formulæ, and a hub is provided for additional strength partly because of the necessary grip on the shaft. The necessary keyways in the bore still further complicate the stress conditions. There are no simple formulæ on generally-accepted methods fully covering the design of pierced disks; the thickening of the web and the addition of the hub are to a large extent empirical and governed by the judgment of the designer.

APPENDIX III.

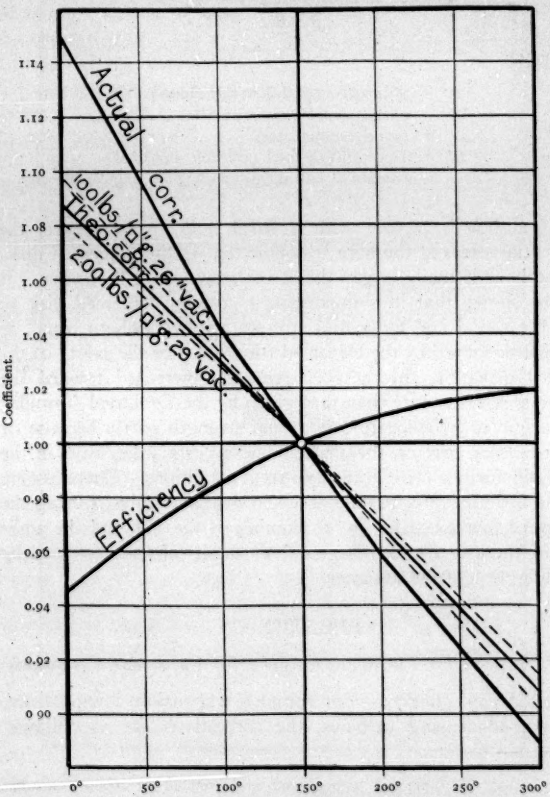
1. *Corrections for Turbines Designed for Particular Conditions.*

(*a*) *Steam Quality.*—For complete expansion, low-pressure, and non-condensing turbines, the corrections are as follows: Between—

0–100° F. superheat, 1 per cent. improvement of steam consumption for every 10° F. superheat.
100–200° F. superheat, 1 per cent. improvement of steam consumption for every 12° F. superheat.
200–300° F. superheat, 1 per cent. improvement of steam consumption for every 14° F. superheat.

The efficiency increases with the superheat, and consequently the actual is larger than the theoretical correction, which is

FIG. a.—APPENDIX III.

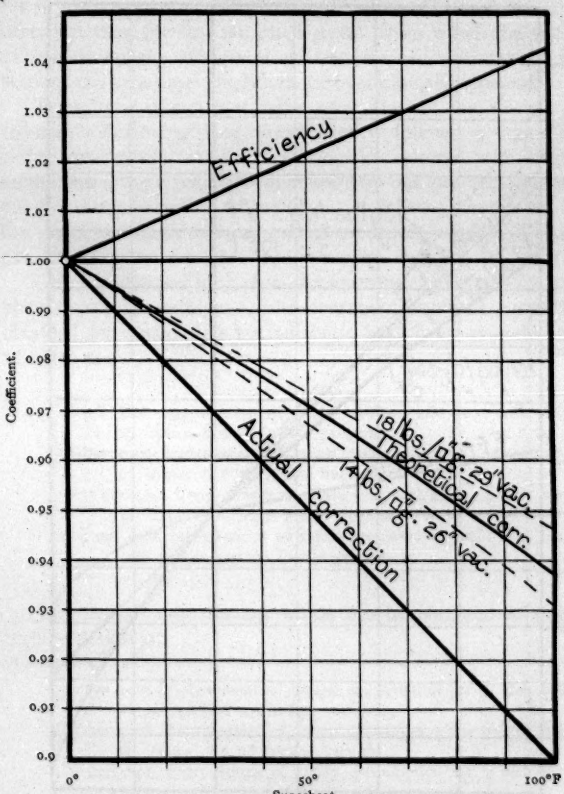


Superheat corrections for high-pressure turbine designed for superheat.

calculated from the variations of the available heat drop in adiabatic expansion. Fig. *a* plots the actual superheat corrections

for high-pressure turbines, together with the change of efficiency and the mean theoretical correction for steam conditions varying

FIG. b.—APPENDIX III.

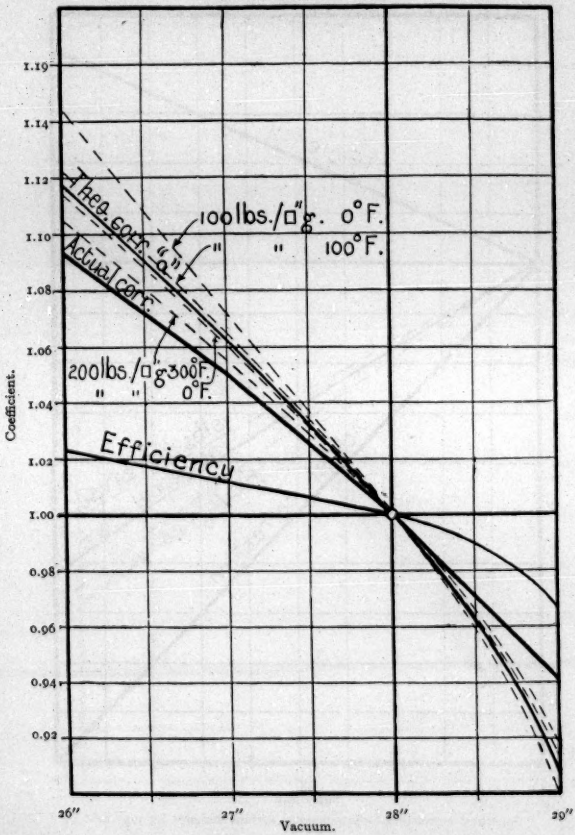


Superheat corrections for low-pressure turbine designed for superheat.

between the limits 100 pounds per square inch gauge pressure, 26 inches vacuum, and 200 pounds per square inch gauge pressure, 29 inches vacuum.

Fig. *b* plots similar values for low-pressure turbines for conditions varying between the limits 14 pounds per square inch

FIG. c.—APPENDIX III.



Vacuum corrections for high-pressure turbine designed for vacuum.

absolute pressure, 26 inches vacuum, and 18 pounds per square inch absolute pressure, 29 inches vacuum.

The improvements in efficiency may be taken as 4.25 per cent. better efficiency at 100° F. superheat than for dry saturated steam; 6.75 per cent. better efficiency at 200° F. superheat than for dry saturated steam; 7.5 per cent. better efficiency at 300° F. superheat than for dry saturated steam, from which the futility of comparing the efficiencies of turbines, without taking into account the superheat conditions in operation, is apparent.

Tests have shown that when steam is wet the efficiency is reduced. Assuming that the efficiency follows a continuous curve for superheat and wet steam when plotted with entropy as the basis, the efficiency will change by one per cent. for each one per cent. variation in wetness. It follows, therefore, that the steam consumption measured as condensed water will be two per cent. higher for each one per cent. increase in moisture.

(*b*) *Vacuum.*—Fig. *c* plots the vacuum corrections for complete expansion turbines. The average theoretical corrections obtained by considering the adiabatic heat drop available may be taken as:

5 per cent. improvement of steam consumption for 1 inch between 26 inches and 27 inches vacuum.
6 per cent. improvement of steam consumption for 1 inch between 27 inches and 28 inches vacuum.
7.75 per cent. improvement of steam consumption for 1 inch between 28 inches and 28½ inches vacuum.
11.5 per cent. improvement of steam consumption for 1 inch between 28½ inches and 29 inches vacuum.

The actual improvement which can be obtained in present turbine design is:

4 per cent. improvement of steam consumption for 1 inch between 26 inches and 27 inches vacuum.
5 per cent. improvement of steam consumption for 1 inch between 27 inches and 28 inches vacuum.
6 per cent. improvement of steam consumption for 1 inch between between 28 inches and 29 inches vacuum.

According to these figures, the efficiencies of equivalent complete expansion turbines designed to utilize different vacua would be:

1 per cent. better efficiency at 26 inches than at 27 inches.
1 per cent. better efficiency at 27 inches than at 28 inches.
1 per cent. better efficiency at 28 inches than at 28½ inches.
2.5 per cent. better efficiency at 28½ inches than at 29 inches.

These figures represent a fair average for steam conditions between the limits of steam pressure at 100 pounds per square inch gauge to 200 pounds per square inch gauge; superheat 0° F. to 300° F.

While the superheat correction is nearly independent of other steam conditions, the vacuum correction depends to a great extent upon the steam pressure, and is much larger for low-pressure turbines, the corrections for which are plotted in Fig. *d*.

For low-pressure turbines, the average theoretical corrections are:

12 per cent. improvement of steam consumption for 1 inch between 26 inches and 27 inches.
13.75 per cent. improvement of steam consumption for 1 inch between 27 inches and 28 inches.
17 per cent. improvement of steam consumption for 1 inch between 28 inches and 28½ inches.
22.5 per cent. improvement of steam consumption for 1 inch between 28½ inches and 29 inches.

The actual improvements which can be obtained with the present low-pressure designs are:

11.5 per cent. improvement of steam consumption for 1 inch between 26 inches and 27 inches vacuum.
13 per cent. improvement of steam consumption for 1 inch between 27 inches and 28 inches vacuum.
14.5 per cent. improvement of steam consumption for 1 inch between 28 inches and 29 inches vacuum.

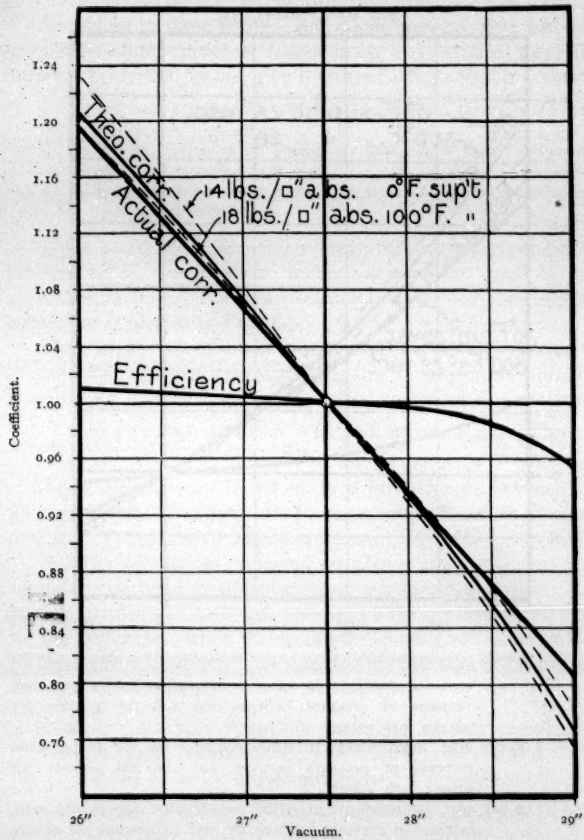
According to these figures, low-pressure turbines using and designed to utilize different vacua efficiencies as follows:

0.5 per cent. better efficiency at 26 inches than at 27 inches.
0.7 per cent. better efficiency at 27 inches than at 28 inches.
1.0 per cent. better efficiency at 28 inches than at 28½ inches.
3.5 per cent. better efficiency at 28½ inches than at 29 inches.

The corrections given represent a fair average for any steam conditions between the limits:

14 pounds per square inch absolute 0° F. superheat.
18 pounds per square inch absolute 100° F. superheat.

FIG. d.—APPENDIX III.

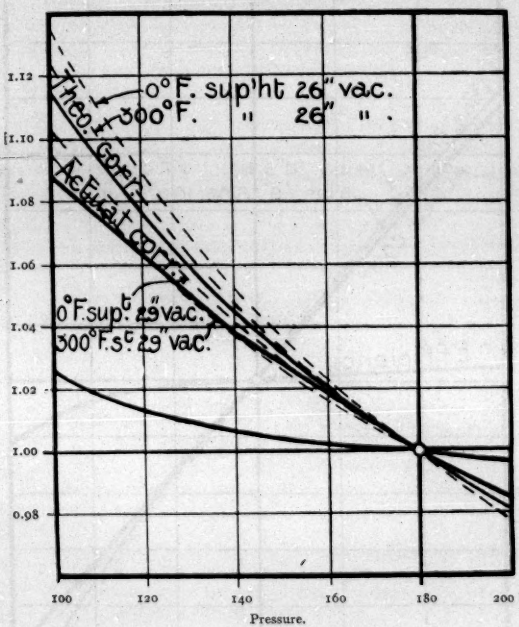


Vacuum corrections for low-pressure turbine designed for vacuum.

(*c*) *Pressure.*—The efficiency which can be obtained with turbines having the same number of stages depends also, but in a lesser degree, upon the steam pressure.

The corrections for pressure in the case of complete expansion turbines are shown in Fig. *e*. The average theoretical corrections are as follows:

FIG. e.—APPENDIX III.



Pressure correction for high-pressure turbine designed for the pressure.

2 per cent. improvement in steam consumption for 10 per cent. increase of pressure between 100 and 140 pounds per square inch gauge.

1.95 per cent. improvement in steam consumption for 10 per cent. increase of pressure between 140 and 180 pounds per square inch gauge.

1.90 per cent. improvement in steam consumption for 10 per cent. increase of pressure between 180 and 200 pounds per square inch gauge.

The actual improvements in steam consumption which can be obtained are:

1.5 per cent. improvement in steam consumption for 10 per cent. increase of pressure between 100 and 200 pounds per square inch gauge.

According to these figures, equivalent high-pressure turbines having the same number of stages, using and designed to utilize different pressures, would give improved efficiencies as follows:

0.4 per cent. better at 180 pounds per square inch than at 200 pounds per square inch gauge.
1.0 per cent. better at 140 pounds per square inch than at 180 pounds per square inch gauge.
1.6 per cent. better at 100 pounds per square inch than at 140 pounds per square inch gauge.

These corrections are a fair average for any steam conditions between 0° F. superheat, 26 inches vacuum, and 300° F. and 29 inches vacuum. For low-pressure turbines the consumption correction is plotted in Fig. *f*.

The range of pressure met with in low-pressure turbines is so small that a pressure correction for the Rankine-cycle efficiency is negligible. The average consumption correction is as follows:

4 per cent. improvement for 10 per cent. increase in pressure between 14 and 18 pounds absolute.

These figures may be taken as a fair average between the limiting steam conditions 0° F. superheat, 26 inches vacuum, and 100° F. superheat, 29 inches vacuum.

All the corrections referred to above are for steam consumptions of turbines utilizing steam conditions for which they have been specially designed, and are of the greatest importance to the purchaser when fixing steam conditions under which turbines are to operate. In addition to the above corrections, however, the following must be considered:

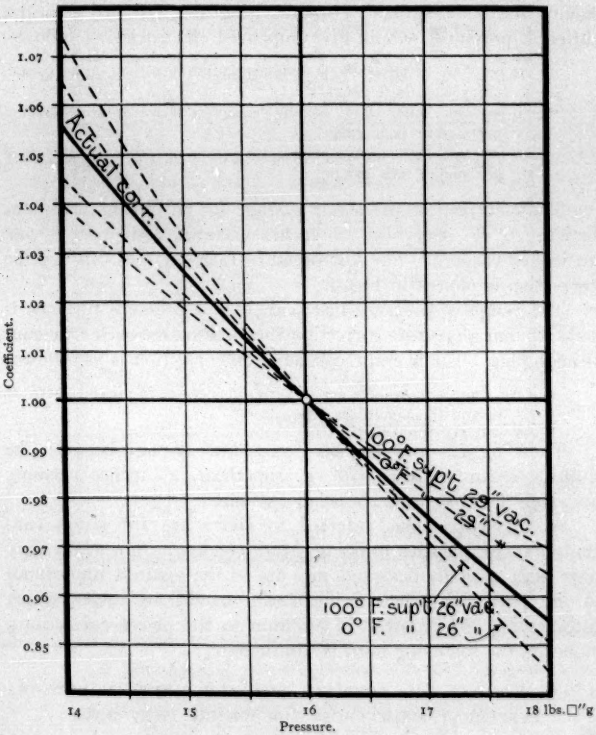
2. CORRECTIONS FOR TURBINES RUNNING UNDER CONDITIONS DIFFERENT FROM THOSE FOR WHICH THEY HAVE BEEN DESIGNED.

(*a*) *Steam Quality.*—When a turbine designed for definite conditions of load, pressure, superheat, and vacuum is tested at conditions other than those for which it has been designed, there must be a variation in the operating conditions.

The superheat corrections for steam consumptions, measured

at certain specific full loads or partial loads, are the same as those already given for turbines designed for different superheats, *i.e.*,—

FIG. f.—APPENDIX III.



Pressure correction for low-pressure turbine designed for the pressure.

1 per cent. improvement of steam consumption for every 10° F. superheat between 0–100° F.

1 per cent. improvement of steam consumption for every 12° F. superheat between 100–200° F.

1 per cent. improvement of steam consumption for every 14° F. superheat between 200–300° F.

Also the corrections for wetness remain the same as above given.

(*b*) *Vacuum.*—An improvement in vacuum of a turbine designed for certain operating conditions will cause a decrease in steam consumption, at the same time increasing its capacity.

If, for instance, an improvement in the vacuum from 27 inches to 28 inches causes a decrease in the steam consumption of 5 per cent., the steam pressure on the initial stages of the turbine will also drop 5 per cent.

The turbine will then be 5 per cent. too large for these conditions, and the steam will be throttled to a greater extent than if the turbine had been designed for 28 inches vacuum. The improvement due to vacuum will therefore be smaller than that already given for turbines designed for various vacua. In the case cited, a 5 per cent. decrease in pressure would, for complete expansion turbines, decrease the improvement due to vacuum by one-half of 1 per cent.

The improvement will be further decreased because the efficiency of the last stages being designed for 27 inches, and working with 28 inches vacuum, will be inferior to that of stages designed to properly handle the larger steam volumes at 28 inches vacuum.

It is apparent, therefore, that the decrease in the steam consumption of a turbine for an increase in vacuum will depend upon the vacuum for which the turbine has been designed.

The correction for partial loads becomes larger for two reasons: (*a*) as the available heat drop becomes less, the change due to vacuum becomes greater; and (*b*) as the total weight of steam flowing through the turbine becomes less, the blading of the last stages is better able to handle the increased volume due to increased vacuum.

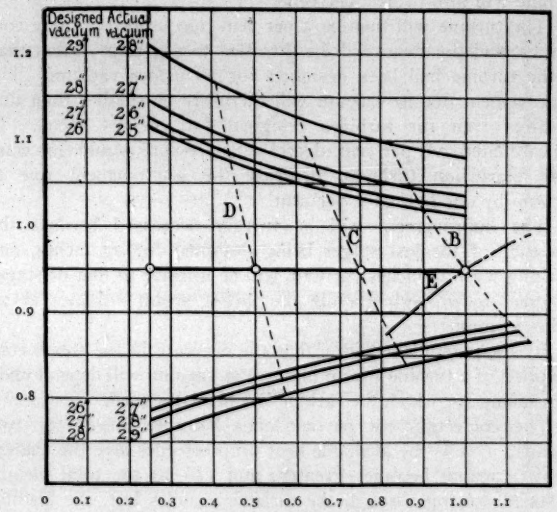
For these reasons, the corrections will be still larger for mixed-pressure turbines where the low-pressure part is too large for the steam quantity used when running on high-pressure steam.

For low-pressure turbines working with vacua other than those for which they were designed, the correction is still greater. If, for example, an improvement of vacuum from 27 inches to 28 inches decreases the steam consumption 13.75 per cent., the steam pressure on the initial stages falls by 13.75 per cent.

As a pressure decrease of 10 per cent. on low-pressure turbines increases the steam consumption by 4 per cent., the correction is reduced from 13.75 per cent. to about 9.5 per cent.

The actual corrections for different loads of turbines designed from 26 inches, 27 inches, 28 inches, and 29 inches vacuum are plotted in Fig. *g* for 1 inch change in vacuum above or below that for which the turbine is designed. When a turbine designed

FIG. g.—APPENDIX III.



Vacuum correction for low-pressure turbines.

for a given vacuum is run at a lesser one, it will not supply the designed full load with the full-load pressure. The total steam quantity remains the same, but since the available heat drop is reduced, the work done will also be reduced. If, for example, a turbine is designed for 26 inches vacuum and is run at 25 inches vacuum, the maximum load at this vacuum will be only 90 per cent. of the designed full load at 26 inches vacuum. The designed full load can, however, be obtained by raising the pressure on the initial stages.

The maximum loads which can be obtained with a vacuum 1 inch above or below that for which a turbine is designed, provided the pressure on the initial stages remains the same, are given by Curve *B* in Fig. *g*. Curves *C* and *D* similarly connect points corresponding to three-fourths maximum load and one-half maximum load.

The intercept corresponding to a maximum load and the Curve *E* gives the ratio of the steam consumption at that maximum load to the consumption of the full load and vacuum for which the turbine is designed.

Pressure Correction.—When the steam pressure on the initial stages is increased, the steam consumption decreases because of the increase of available energy. For high-pressure turbines the improvement of steam consumption is 1.5 per cent. for 10 per cent. increase of pressure. For low-pressure turbines the improvement of steam consumption is 4 per cent. for 10 per cent. increase of pressure.

If, however, the turbine is working on constant load and the pressure before the governor valve is increased, the pressure on the initial stages of the turbine remains practically constant, and the only advantage gained is that due to the increased superheat resulting from throttling the steam.

In this case the corrections for full or partial loads will be the same for high-pressure and low-pressure turbines, namely, one-half of 1 per cent. improvement of steam consumption for every 10 per cent. increase of pressure.

Iron-carbon and Iron-silicon Alloys. E. GUMLICH and P. GOERENS. (*Faraday Soc. Trans.*, viii, 98.)—An extensive series of tests has shown that the presence of large amounts of silicon prevents, even with rather quick cooling, the formation of the extremely injurious solid solution of carbon and iron, the carbon appearing only in the shape of the much less injurious pearlite. Under the influence of silicon, even the pearlite is decomposed by a prolonged process of annealing into ferrite and temper-carbon, and thus becomes almost entirely passive magnetically. To produce this effect with certainty, at least from three to four per cent. of silicon is necessary in the material. The fact that thin sheet metal containing carbon and less than three per cent. of silicon may show exceedingly good magnetic properties must have other reasons.

Crystolon—Silicon Carbide. F. A. J. FITZGERALD. (*Met. Chem. Eng.*, x, 519.)—At sufficiently high temperature in an oxidizing atmosphere crystolon decomposes to form SiO_2 and CO, or, in a neutral or reducing atmosphere, to form Si vapor and C in the form of the original crystals. Great care is required in mixing up the charge, viz., 60 SiO_2 and 36 C, for a slight excess of SiO_2 in any part of the furnace results in the formation of Si. The working temperature range is about 400°, below which the reaction does not begin and above which the SiC is decomposed with a loss of Si, and, if the temperature becomes sufficiently high, the formation of graphite. The furnace, which takes about 700 kilowatts, starting at 215 volts and ending with 9000 ampères at 80 volts, and a power factor of 0.9, is built up with the charge surrounding a horizontal core of granular coke resistor.

Production of Pig Iron in 1912. ANON. (*Board of Trade J.*, Feb. 20, 1913.)—According to a Bulletin issued by the American Iron and Steel Institute, the production of pig iron in the United States in 1912 was as follows; the figures for 1911 and 1910 are given for comparison:

	1910 Tons	1911 Tons	1912 Tons
Bessemer and low phosphorus	11,245,642	9,409,303	11,667,656
Basic	9,084,608	8,520,020	11,394,477
Charcoal	396,507	278,676	347,025
Ferro-manganese	71,376	74,482	125,379
Spiegeleisen	153,055	110,236	96,346
Foundry ferro-silicon, etc.	6,352,379	5,256,830	6,096,254
	27,303,567	23,649,547	29,727,137

Absorption of Creosote by the Cell-walls of Wood. C. H. TEESDALE. (*U. S. Dept. Agric.*, Circular No. 200.)—The location of the creosote absorbed by wood is important in so far that if the cell-walls absorb creosote a weakening effect may be expected similar to that produced by moisture in wood. A number of samples of wood dried in an oven at 100° C. for 24 hours were treated with creosote for 1½ hours at 82° C. and a pressure of 150 pounds per square inch, and then raised to a temperature of 104.5° C. for 5 hours. The volume of the samples was measured before and after treatment, and the following average increases in volume noted: Yew—Heartwood 6.81, sapwood 10.70. Hemlock—Heartwood 7.30. Hard Maple—Heartwood 8.14 per cent. It follows that a decided swelling occurs in wood impregnated with creosote. The tests indicate that this swelling is caused by the absorption of the creosote by the cell-walls.

NOTES FROM THE U. S. BUREAU OF STANDARDS.*

SCALES AND WEIGHING MACHINES.

In the next fiscal year, beginning July 1, the Bureau will have an appropriation of $25,000 for an equipment for standardizing large scales, such as track scales, etc.

This equipment will serve, first, to furnish standard weights of large size for standardization purposes; secondly, it will be used in conducting investigations and experiments upon the large scales and weighing machines.

As a standard it will be used as a means of standardizing the master scales used by the officials of States who are authorized to test railroad and warehouse scales; and as a standard for master scales of railroads and other concerns who employ such a scale for standardizing the weight of the test weight cars used for adjusting the regular service scales.

The equipment will also be available for determining the condition of scales in cases of disputes in commercial transactions in which weights are involved, and so provide equitable means of settlement.

The investigations will include the test of scales used in the regular railroad and warehouse service, in order to determine the accuracy of scales used under various circumstances.

The scales will be studied to determine the value and reliability of the various designs of scales and the efficiency of various systems of inspection, test, and maintenance. These data will be used in assisting the development of uniform and reliable specifications for the design and maintenance of scales, and so further establish accurate weights in commercial transactions.

Wagon and warehouse scales are generally tested with a load which is but a fractional part of their capacity. The test equipment will be used to test these scales under full load. The data obtained will be used in establishing necessary value of the test load required to insure the proper action of the scale at full

* Communicated by the Bureau.

load. In order to be independent from master scales, etc., the equipment will consist of test weights aggregating 100,000 pounds. The weights will consist of 10,000 pounds of 50-pound weights, four 2500-pounds weights, and eight 10,000-pound weights. A truck will be provided for carrying the weights while they are being shifted from point to point upon track scales during the test. The weights and truck will be housed and transported in a car specially designed for the purpose, and this car will be provided with power for handling the weights rapidly by means of a specially designed crane.

CONFERENCE ON WEIGHTS AND MEASURES.

THE Eighth Annual Conference on Weights and Measures was held May 14–17, 1913, at the National Bureau of Standards in Washington. Representatives of the various States and cities having weights and measures officials were present. This Conference is the coöperative effort on the part of those interested in weights and measures to place the inspection service upon a thorough scientific and practical basis. A notable feature of the reports was with respect to the large number of States which had adopted, in whole or in part, the model weights and measures law recommended by the Conference.

The Secretary of Commerce, Hon. William C. Redfield, delivered the address of welcome. Dr. S. W. Stratton, the Director of the Bureau, presided at the Conference. The principal technical papers related to the testing of gas meters (M. H. Stillman, Bureau of Standards), testing of water meters (W. F. Stutz, Bureau of Standards), design of capacity measures (R. Y. Ferner, Bureau of Standards). Chief Engineer A. Bousfield, of the Fairbanks Company, gave a talk on the "Design of Scales." A report on legislation for the past year was made by F. S. Holbrook, inspector of weights and measures for the Bureau of Standards. Mr. L. A. Fisher, secretary of the Conference, read the report of the work of the organization since its last meeting. Mr. R. W. Smith, of Minnesota, discussed uniformity in State laws on weights per bushel of commodities. Col. W. C. Haskell, of Washington, D. C., reported upon the difference in the amount of a bushel of a commodity when sold by weight and when sold by measure. Mr. C. A.

Briggs, of the Bureau of Standards, described some experiments on scales and weighing and certain technical features of scale action and construction. The functions of a State sealer were described by Commissioner H. H. Henry, of Vermont. Commissioner C. C. Neale, of Minnesota, discussed "Seals and the Methods of Sealing."

Probably the most important single question taken up by the Conference related to the establishment of "Tolerances and Specifications" for weights and measures. The report on this subject, presented by John C. Connors, was adopted by the Conference. A basis is thus established for the unification of the allowed tolerances on weights and measures used in daily trade.

In conclusion amendments and additions to the model law were proposed by Mr. Holbrook, of the Bureau of Standards.

In connection with the Conference an exhibition of weighing and measuring appliances was made by the manufacturers. Altogether the Eighth National Conference was the most successful which has yet been held. The proceedings will be published for general distribution by the Bureau of Standards. Appended are synopses of two of the papers. Abstracts of other papers will be published in the next number of this journal.

SCALES.

EXPERIMENTS ON SCALES AND WEIGHING—TECHNICAL FEATURES OF SCALE ACTION AND CONSTRUCTION.

By C. A. Briggs.

THIS paper dealt with technical questions of scales and weighing. The subject matter was divided into two parts.

In the first the results of tests and experiments bearing upon the subject were presented. Results of weighing under special conditions were given and devices for the experimental determination of deflections in beams and structural parts were described.

In track scales the bridge is generally constructed upon the continuous girder principle, and the distribution of a load among the supports is somewhat uncertain. An experimental method for determining this distribution was proposed.

In the second part of the paper theoretical subjects bearing upon the mechanical action of scales and their construction were

given and questions relating to the development of the subject from a technical viewpoint were outlined.

It was pointed out that generally recognized engineering principles have been applied to scales only in the last few years, and that consequently considerable remained to be done in establishing satisfactory working principles and practice.

TESTING OF DRY GAS METERS.

By M. H. Stillman.

THE paper was intended to present very briefly the problems involved in testing the ordinary dry gas meter and was divided into three parts:

A. Description of the ordinary type of dry gas meter.

B. Comparison of the meter with a calibrated meter or prover.

C. Comparison of the calibrated meter or prover with the standard cubic-foot bottle.

Emphasis was laid upon the necessity of keeping the testing medium (gas or air) involved in the comparisons at very nearly constant temperature, pressure and relative humidity. Since the ordinary consumer's dry meter measures the *volume* of gas passing, the most direct and natural way to test this type of meter is to pass a *known* volume of gas through the meter and notice whether the indicated volume is correct. The present methods of accomplishing this consist generally in either:

1. Passing the testing medium (air or gas) through a standard meter and the meter under test in series.
2. Supplying the testing medium to the meter under test from a meter power.

In order to obtain correct results by the above methods, the following conditions are requisite:

1. That when using a standard test meter this meter shall correctly indicate the volume of gas passed through it.

2. That when using a prover the prover shall correctly indicate the volume of gas *delivered* by it.

3. That when using either standard meter or prover there must be very little or no change in volume of the testing medium during its passage from the standard apparatus *to* and *through* the tested apparatus.

And, in order that the above three requirements be fulfilled:

1. The meter prover or test meter must be correctly calibrated.

2. The testing medium (air or other gas) and every part of the system which might influence the temperature of the testing medium during the test must be at the same temperature and remain at very nearly constant temperature during the tests.

3. The testing medium must not during the test absorb any vapors or other gases which may change its volume appreciably.

The errors due to the use of water as a displacing and sealing liquid were briefly discussed. The paper was illustrated with lantern slides and apparatus.

NOTE ON THE CONSTRUCTION OF THERMOPILES.

By W. W. Coblentz.

WITHIN the past few years rapid strides have been made in the development of sensitive thermopiles. In this development experiments have been greatly assisted by the theoretical principles of thermopile construction enunciated by Johansen,[1] who shows that the radii of the two wires of the element must be so chosen that the ratio between the heat conductivity and the electrical resistance is the same in both. Johansen's practice, however, is poor in that he used iron wire which rusts rapidly and in that the "cold," unexposed junctions were joined directly to the metal posts in the frame supporting the junctions. This prevents the unexposed junctions from quickly attaining the same temperature as the "hot" junctions, and hence tends to cause a "drift," as was found by Moll,[2] and more recently by the writer. The "cold" junctions should be covered with receivers having the same size and emissivity as the "hot" junctions, and they should be free in the air so that there will be no drift with the variation in temperature which is caused by the incident radiation. In the Hilger thermopile, which embodies the Johansen principles, the "cold" junctions appear to be joined to the metal posts in the ivory frame, hence are liable to cause a "drift" of the galvanometer needle, as was found by Moll and others.

[1] Johansen, *Ann. der. Phys.* (4), 33, p. 517, 1910.

[2] Moll, Dissertation, Utrecht, 1907.

It is, of course, easier to construct such a thermopile, but it is not considerate of the needs of the one who must use such devices. With this thought in mind, the writer constructs his thermopiles of bismuth and silver[3] with the "cold" junctions exposed freely in the air, and having vanes symmetrical with the "hot" junctions, which is an important, if not the most important, desideratum in thermopile construction.

The additional labor involved in constructing such a thermopile is compensated for by a greater ease of operation with a highly sensitive galvanometer, such as is required in energy measurements in the extreme ends of the spectrum.

Production and Consumption of Coal and Lignite. (*Board of Trade Journal*, Jan. 30, 1913.)—*Production.*—The production of coal in the five principal coal-producing countries of the world in 1909, 1910, and 1911 was as follows, in tons of 2240 pounds:

Countries	1909 Tons.	1910 Tons.	1911 Tons.
United Kingdom	263,774,000	264,433,000	271,899,000
Germany	146,397,000	150,372,000	*158,164,000
France	36,519,000	37,030,000	38,023,000
Belgium	23,140,000	23,532,000	*22,683,000
United States	411,432,000	447,854,000	†443,025,000

* Provisional figures.
† Including lignite.

In the United Kingdom, Germany, and France the production in 1911 exceeded that of any previous year, while in Belgium it fell below that of any of the five previous years. The average annual output in the above-mentioned countries was 870,000,000 tons in the five years 1906–1910, an increase of over 170,000,000 tons on the average of the previous quinquennium. Of the other countries, Russia alone has a production exceeding 20,000,000 tons yearly. The total known production of the world (exclusive of brown coal or lignite) was about 1,050,000,000 tons in 1911.

Consumption.—In 1911 the consumption of coal was as follows: United States (including lignite), 425,422,000 tons; United Kingdom, 184,859,000 tons; Germany, 133,437,000 tons; France, 57,133,000 tons; Russia, 28,298,000 tons; Belgium, 24,126,000 tons.

Lignite.—The statistics of lignite production show that the chief producing countries are Germany, Austria, and Hungary, which in 1910 produced 68,430,000 tons, 24,729,000 tons, and 7,610,000 tons respectively; in 1911 the output in Austria was 24,859,000 tons, with 72,575,000 tons in Germany. The lignite produced in the United States is included in the figures for coal.

---

[3] Coblentz, *Bull. Bur. Standards*, 9, p. 7, 1912.

THE FRANKLIN INSTITUTE

(Proceedings of the Stated Meeting held Wednesday, May 21, 1913.)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 21, 1913.

PRESIDENT WALTON CLARK *in the Chair.*

Additions to membership, 46.

The following proposed amendment to the By-Laws was presented for first reading:

Article IV, Section I, of the By-Laws to be amended by striking out everything after "January," in the third line, and substituting the following words: "March in each year shall pay, in advance, for the current year, one-half of the annual dues," so that the section as amended will read:

> "The annual payment of fees for membership shall be due and payable on the first of October in each year, in advance; but all members elected after the 31st of March in each year shall pay, in advance, for the current year, one-half of the annual dues."

The Chairman announced that the object of the meeting was to present the Elliott Cresson Medal to the distinguished scientists who had been recommended for this award by the Committee on Science and the Arts, and called upon Dr. Harry F. Keller to introduce them.

Dr. Keller then introduced Mr. Emile Berliner, of Washington, D. C., Dr. Isham Randolph, of Chicago, Ill., and Dr. Charles Proteus Steinmetz, of Schenectady, N. Y.

The Chairman presented the medal and certificate to each of these gentlemen.

Dr. Keller read letters of acknowledgment from Lord Rayleigh and Sir William Ramsay, of London, and Dr. Emil Fischer, of Berlin, Germany, to whom the award had been forwarded through the United States Government.

Addresses were then made by the recipients of the medals, as follows:

"Development of the Talking Machine," by Mr. Emile Berliner.

"The Imaginative Faculty in Engineering," by Dr. Isham Randolph.

"Some Electrical Problems Awaiting Solution," by Dr. Charles P. Steinmetz.

After a vote of thanks to the speakers the meeting adjourned.

R. B. OWENS,
Secretary.

[A full account of the meeting will appear in the July number.]

COMMITTEE ON SCIENCE AND THE ARTS.

(*Abstract of Proceedings of the Stated Meeting held Wednesday, May 7, 1913.*)

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, May 7, 1913.

MR. J. A. P. CRISFIELD *in the Chair.*

The following report was presented for final action:

No. 2526.—C. Francis Jenkins's Motion-Picture Apparatus. Referred back.

The following new subjects were accepted for examination:

No. 2534.—Reno's Escalator.
No. 2535.—Tirrell Voltage Regulator.
No. 2536.—Coolidge's Malleable Tungsten.
No. 2537.—Cooper-Hewitt Mercury Rectifier.
No. 2538.—Pohle Air-Lift.
No. 2539.—Duplex Copper-Steel Wire.
No. 2540.—Upton & Lewis's Fatigue Testing Machine.
No. 2541.—Guillaume's Alloy "Invar."

R. B. OWENS,
Secretary.

SECTIONS.

Mechanical and Engineering Section.—A meeting of the section was held in the Hall of the Institute on Thursday evening, April 24th, at 8 o'clock.

The meeting was called to order by the president of the section, Mr. George R. Henderson, who introduced Mr. J. M. Rusby, M.E., Engineer of Tests, United Gas Improvement Company, and member of the Institute.

Mr. Rusby presented a communication on "Industrial Combustible Gases," in which he dealt with the qualities and origin or methods of production of the important gases used in the arts.

After describing the physical properties of the various gases, the speaker reviewed their origin and, in the case of the artificial gases, described methods of their manufacture.

He then considered in detail the advantages of coal, oil, and carburetted water gas for domestic purposes.

His remarks were interesting and were well illustrated by numerous lantern slides.

A brief discussion followed Mr. Rusby's paper, and, after a vote of thanks to the speaker, the meeting adjourned.

WILLIAM E. BULLOCK,
Acting Secretary.

Mechanical and Engineering Section.—A meeting of the section was held on Thursday evening, May 1st, at 8 o'clock, in the Hall of the Institute.

The meeting was called to order by the president of the Institute, who introduced Dr. Ralph Modjeski, Consulting Engineer, Chicago, Ill.

Dr. Modjeski presented a communication on "The Design of Large Bridges, with Special Reference to the New Quebec Bridge."

As an introductory, the speaker dealt with the properties of materials used in modern bridge construction. He then considered salient features of the design of several completed structures and also of some in course of construction.

His remarks on the Quebec Bridge referred to the original design and to the causes of failure of the first bridge. He concluded with a description of the new bridge.

Dr. Modjeski illustrated his paper with lantern slides and diagrams of full-size chord sections. Through these media his remarks were especially interesting and instructive.

Adjourned.

WILLIAM E. BULLOCK,
Acting Secretary.

ON THE TRAIL OF THE SPANISH PIONEERS.

Mr. Frederick Monsen, F.R.G.S., artist and explorer, again delivered a lecture in the Hall of the Institute on the evening of Friday, April 25, 1913, on this occasion describing the country traversed by the Spanish pioneers, early in the sixteenth century, under the leadership of Hernando Cortes. Incidentally the speaker discussed the present conditions in Mexico and the southwestern portions of the United States.

The natural wonders of these countries were shown and described by means of beautifully-colored lantern slides made from photographs taken by Mr. Monsen, interspersed by many interesting tales of travel and exploration.

MEMBERSHIP NOTES.

Elections to Membership.

(*Stated Meeting of the Board of Managers, May 14, 1913.*)

RESIDENT.

MR. LEO D. FIRMAN, 1730 Girard Avenue, Philadelphia, Pa.
MR. NATHAN HAYWARD, 1230 Arch Street, Philadelphia, Pa.
MR. W. H. HEULINGS, JR., The J. G. Brill Company, Philadelphia, Pa.
MR. JOSEPH D. ISRAEL, The Philadelphia Electric Company, Tenth and Chestnut Streets, Philadelphia, Pa.
MR. CHARLES H. LAWALL, 39 South Tenth Street, Philadelphia, Pa.

MR. WILLIAM MAUL MEASEY, 1328 Chestnut Street, Philadelphia, Pa.
MR. DAVID R. RICHIE, S. L. Allen & Co., Fifth and Glenwood Avenue, Philadelphia, Pa.
MR. ROBERT W. WITHINGTON, American Insulating Machinery Company, Philadelphia, Pa.
MR. E. A. WOLFE, Westinghouse Electric and Manufacturing Company, North American Building, Philadelphia, Pa.

NON-RESIDENT.

MR. WILLARD S. ATKINSON, Ashland, N. J.
PROF. ERNEST J. BERG, Department of Electrical Engineering, University of Illinois, Urbana, Ill.
MR. A. W. BERRESFORD, The Cutler-Hammer Manufacturing Company, Milwaukee, Wis.
MR. JOHN W. BRASSINGTON, The Pusey & Jones Company, Wilmington, Del.
MR. H. W. BUCK, 49 Wall Street, New York, N. Y.
DR. M. E. COOLEY, Dean, Department of Engineering, University of Michigan, Ann Arbor, Mich.
MR. G. L. COPPAGE, The Pusey & Jones Company, Wilmington, Del.
MR. ERNEST H. DAVIS, The Edison Electric Illuminating Company, Williamsport, Pa.
MR. ALEX. DOW, 18 Washington Avenue, Detroit, Mich.
MR. THOMAS DUNCAN, Duncan Electric Manufacturing Company, LaFayette, Ind.
MR. CHARLES L. EDGAR, Edison Electric Illuminating Company, 70 State Street, Boston, Mass.
MR. CARLETON ELLIS, 92 Greenwood Avenue, Montclair, N. J.
MR. FRANK R. FORD, 115 Broadway, New York, N. Y.
MR. ALBERT H. GFRORER, Box 145, West New Brighton, N. Y.
MR. B. GHERARDI, American Telephone and Telegraph Company, 15 Dey Street, New York, N. Y.
MR. P. G. GOSSLER, A. B. Leach & Co., 149 Broadway, New York, N. Y.
MR. EDWIN W. HAMMER, 55 John Street, New York, N. Y.
MR. J. W. HOWELL, General Electric Company, Harrison, N. J.
MR. THADDEUS MERRIMAN, 165 Broadway, New York, N. Y.
MR. CHARLES H. MERZ, 32 Victoria Street, Westminster, London, Eng.
DR. RALPH MODJESKI, 220 South Michigan Avenue, Chicago, Ill.
MR. WILLIAM S. MURRAY, The N. Y., N. H. & Hartford Railroad Company, New Haven, Conn.
MR. H. S. NOBLE, Renovo, Pa.
MR. A. P. PRENDERGAST, Superintendent of Motive Power, The B. & O. Railroad Company, Baltimore, Md.
LIEUT.-COL. SAMUEL REBER, Army Building, 39 Whitehall Street, New York, N. Y.
MR. E. W. RICE, JR., General Electric Company, Schenectady, N. Y.
MR. ROBERT RIDGWAY, 154 Nassau Street, New York, N. Y.
MR. RUSSELL ROBB, Stone & Webster, 147 Milk Street, Boston, Mass.

MR. DWIGHT P. ROBINSON, Stone & Webster Engineering Corporation, 147 Milk Street, Boston, Mass.
MR. F. A. SEIBERLING, The Goodyear Tire and Rubber Company, Akron, O.
MR. S. D. SPRONG, Edison Electric Illuminating Company, 360 Pearl Street, Brooklyn, N. Y.
MR. W. C. SPRUANCE, JR., E. I. du Pont de Nemours Powder Company, Wilmington, Del.
MR. CHARLES A. STONE, Stone & Webster, 147 Milk Street, Boston, Mass.
MR. CHARLES W. STONE, General Electric Company, Schenectady, N. Y.
MR. F. M. TAIT, The Dayton Power and Light Company, Home Telephone Building, Dayton, Ohio.
MR. F. L. O. WADSWORTH, 1347 Oliver Building, Pittsburgh, Pa.
MR. W. F. WELLS, 360 Pearl Street, Brooklyn, N. Y.

Changes of Address.

DR. LOUIS DUNCAN, 50 Church Street, New York City.
MR. J. McGOWAN, JR., Box 287, Camden, N. J.
MR. HORACE C. KNORR, Primos, Pa.
MR. JOHN C. NOWELL, 210 Post Street, San Francisco, Cal.
MR. LUCIEN E. PICOLET, P. O. Box 4, Bala, Pa.

NECROLOGY.

Mr. J. W. Ridpath, Jenkintown, Pa.

LIBRARY NOTES.

Purchases.

ADLER, A. A.—The Theory of Engineering Drawing. 1912.
American Electrochemical Society.—Transactions, vol. 22. 1912.
BARCLAY, W. R., and C. H. HAINSWORTH.—Electroplating. 1912.
BRADLEY, F. A.—Pumping and Water Power. 1912.
BARTHEL, C.—Die Methoden zur Untersuchung von Milch und Molkereiprodukten. 1911.
BLONDEL, A. E.—Synchronous Motors and Converters. 1913.
DARLING, C. R.—Pyrometry. 1911.
Engineering Index Annual. 1912.
FRENCH, A. W., and H. C. IVES.—Stereotomy. 1911.
FRENCH, T. E.—A Manual of Engineering Drawing. 1911.
FRYE, A. I.—Civil Engineers' Pocket-book. 1913.
HATSCHEK, E.—An Introduction to the Physics and Chemistry of Colloids. 1913.

HEARSON, H. R.—The Manufacture of Iron and Steel. 1912.
HIRSCHFELD, C. F., and T. C. ULBRICHT.—Gas Power. 1813.
HOOKER, A. H.—Chloride of Lime in Sanitation. 1913.
JANSKY, C. M.—Electrical Meters. 1913.
MCLOUGHLIN, T. S.—Questions and Answers on the National Electrical Code. 1912.
PRICE, W. B., and R. K. MEADE.—The Technical Analysis of Brass. 1911.
PROCTOR, H. R.—Leather Chemists' Pocket-book. 1912.
RODENHAUSER, W., and I. SCHOENAWA.—Electric Furnaces in the Iron and Steel Industries. 1913.
STARLING, S. G.—Electricity and Magnetism. 1912.
TORREY, J., and A. S. MANDERS.—The Rubber Industry. No date.
USBORNE, P. O. G.—The Design of Simple Steel Bridges. 1912.
WALKDEN, S. L.—Aëroplanes in Gusts. 1912.
WILDA, H.—Steam Turbines. 1912.
WODISKA, J.—A Book of Precious Stones. 1910.

Gifts.

Baylor University, Announcement of 24th Summer Quarter, June 9–August 29. Waco, Texas, 1913. (From the University.)
Canada Department of Mines, Memoir No. 17–E, Geology and Economic Resources of the Larder Lake District, Ontario, by Morley E. Wilson. Ottawa, 1912. (From the Department.)
Canada Department of Mines, Memoir No. 35, Reconnaissance Along the National Transcontinental Railway in Southern Quebec, by John A. Dresser. Ottawa, 1912. (From the Department.)
Canada Experimental Farms, Reports 1912. Ottawa, 1912. (From Department of Agriculture.)
Catholic University of America, Announcements of the School of Sciences, 1913–1914. Washington, D. C., 1913. (From the University.)
Catholic University of America, School of Law Announcements, 1913–1914. Washington, D. C., 1913. (From the University.)
Children's Aid Society, 31st Annual Report. Philadelphia, 1912. (From the Society.)
College of Physicians of Philadelphia, Transactions, 3rd series, vol. 34. Philadelphia, 1912. (From the College.)
Connecticut Public Utilities Commission, 1st Report, 1912. Hartford, 1913. (From the Commission.)
Engineers' Society of Pennsylvania, Year Book 1913. Harrisburg, no date. (From the Society.)
Glasgow Iron Company, Catalogue 1912. Philadelphia, 1912. (From the Company.)
Hebrew Technical Institute, Catalogue 1913. New York City, 1913. (From the Institute.)
Illinois Annual Coal Report, 31st, 1912. Springfield, 1913. (From the State Mining Board.)

Institution of Civil Engineers, Minutes of Proceedings, vol. 191, 1912–1913. London, 1913. (From the Institution.)

Knox College, Catalogue 1912–1913. Galesburg, Ill., 1913. (From the College.)

Leland Stanford Junior University, Publications: Dudley Memorial Volume and The Fishes of the Stanford Expedition to Brazil, by Edwin Chapin Starks. Stanford University, Cal., 1913. (From the University.)

Library of Congress, Classification Class Q, Science. Washington, D. C., 1913. (From the Library.)

Little Falls Board of Public Works, 18th Annual Report, 1912. Little Falls, N. Y., no date. (From the Board.)

Locomotive and Carriage Superintendents' Committee, Proceedings 1912. Bombay, India, no date. (From the Committee.)

Louisiana State University, Catalogue 1913. Baton Rouge, 1913. (From the University.)

Medford Water and Sewers Commissioners, Annual Report, 1912. Melrose, Mass., 1912. (From the Commissioners.)

Minnesota Historical Society, 17th Biennial Report. St. Paul, 1913. (From the Society.)

New York State Public Service Commission for the First District, Proceedings, vol. 7. New York City, 1912. (From the Commission.)

Northern Central Railway Company, 58th Annual Report, 1912. Philadelphia, 1913. (From the Secretary.)

Nova Scotia Department of Mines, Report 1912. Halifax, 1912. (From the Commissioner Public Works and Mines.)

Numismatic and Antiquarian Society of Philadelphia, Proceedings, vol. 26, 1910, 1911, 1912. Philadelphia, 1913. (From the Society.)

L'Observatoire National D'Athenes, Annales Tome 6. Athens, Greece, 1912. (From the Observatory.)

Ohio Geological Survey, (4th series) Bulletin No. 15, The Devonian and Mississippian Formations of Northeastern Ohio. Columbus, 1912. (From the State Geologist.)

Ontario Horticultural Societies, 7th Annual Report, 1912. Toronto, Can., 1913. (From the Department of Agriculture.)

Ontario Vegetable Growers' Association, 8th Annual Report, 1912. Toronto, Can., 1913. (From the Ontario Department of Agriculture.)

Pacinotti, Antonio, Descrizione di una Macchinetta Elettro-Magnetica. Bergamo, Italy, 1912. (From L'Associazione Elettrotecnica Italiana.)

Pennsylvania Railroad Company, 66th Annual Report, 1912. Philadelphia, no date. (From the Secretary of the Company.)

Philadelphia City Institute, 61st Annual Report. Philadelphia, 1913. (From the Institute.)

Philippine Bureau of Education, 12th Annual Report of the Director, June 30, 1912. Manila, P. I., 1912. (From the Bureau.)

Providence Public Library, 35th Annual Report, 1912. Providence, R. I., 1913. (From the Library.)

Rose Polytechnic Institute, 31st Annual Catalogue, 1912–1913. Terre Haute, Ind., 1913. (From the Institute.)

Royal Scottish Museum, Guide to the Collection of Egyptian Antiquities. Edinburgh, 1913. (From the Museum.)

Smithsonian Institution. Smithsonian Meteorological Tables, 3rd edition, 1907. Washington, D. C., 1907. (From the Institution.)

Taunton Water Board, Report for 1912. Taunton, 1913. (From the Board.)

United States Geological Survey, Mineral Resources of the United States for 1911. 2 volumes. Washington, D. C., 1911 and 1912. (From the Survey.)

University of Arizona, Register 1912–13. Tucson, Ariz., 1913. (From the University.)

University of Colorado, Catalogue 1912–1913. Boulder, Col., 1913. (From the University.)

University of Illinois, Report 1912. Springfield, Ill., 1912. (From the University.)

University of Minnesota School of Mines Experimental Station, Bulletin No. 1, Iron Mining in Minnesota, by Charles E. van Barneveld. Minneapolis, 1912. (From the University of Minnesota Library.)

Vermont Agricultural Experimental Station, 24th and 25th Annual Reports, 1910–1912. Burlington, 1911–1912. (From the Experimental Station.)

Western Australia Geological Survey, Bulletin No. 43, Petrological Contributions to the Geology of Western Australia, by R. A. Farquharson, and Bulletin No. 47, The Mining Geology of the Kanowna Main Reef Line, by T. Blatchford and J. T. Jutson. Perth, 1912. (From the Agent General for Western Australia.)

Wyoming Insurance Laws, 1913. Laramie, 1913. (From the State Auditor.)

Zoological Society of Philadelphia, 41st Annual Report. Philadelphia, 1913. (From the Society.)

BOOK NOTICES.

A TEXT-BOOK OF PHYSICS, by H. E. Hurst and R. T. Lattey. 3 volumes, illustrations, 12mo. New York, D. Van Nostrand Company, 1912. Price, in cloth, $4.

This text-book is published in three volumes. Vol. I contains Dynamics and Heat; Vol. II, Magnetism, Statical Electricity, and Current Electricity; Vol. III, Sound and Light. "The scope of the book was primarily the Preliminary Examination in Physics in the Oxford Natural Science School, but a certain amount of additional matter has been introduced to render the treatment more complete and more generally useful." The subject-matter has been well selected and the treatment is clear and concise. At the end of each chapter there are a number of excellent examples. The fundamental principles and laws are well illustrated with experiments which are so carefully described that the book can be used as a laboratory manual. On this account it has a decided advantage over many of the present texts on this subject. It is the reviewer's opinion that a brief out-

line of the electron theory of electricity, of the properties of the X-rays and the radiations from the radioactive substances, and also a description of some of the more sensitive optical instruments, such as the Lummer-Brodhun photometer, the Michelson interferometer, and the diffraction grating, together with a few of their applications to measurements of precision, would greatly increase the usefulness of the book. The volumes deserve serious consideration by all who are interested in teaching the elements of physics.

JAMES BARNES.

PUBLICATIONS RECEIVED.

The Motor and the Dynamo, by James Loring Arnold, Ph.D., Professor of Electrical Engineering, New York University. 178 pages, illustrations, 8vo. Easton, Chemical Publishing Company, 1913. Price, in cloth, $1.50.

General Index to the Chemical News, Vols. 1 to 100. 712 pages, quarto. London, Chemical News Office, 1913. Price, in cloth, £2.

Konstant auftretende secundäre Maxima und Minima in dem jährlichen Verlauf der meteorologischen Erscheinungen von Dr. Van Rijckevorsel. Achte Abteilung. 22 pages, illustrations, tables. Rotterdam, W. J. Van Hengel, 1913.

National Association of Cotton Manufacturers: Papers presented at the annual meeting of the Association held at Boston, Mass., April 23 and 24, 1913. 18 pamphlets, illustrations, 8vo. Boston, Association, 1913.

U. S. Department of Agriculture, Forest Service: Review of Forest Service Investigations, vol. 2. 92 pages, illustrations, plates, 8vo. Washington, Government Printing Office, 1913.

U. S. Bureau of Mines: Monthly Statement of Coal-mine Accidents in the United States, January and February, 1913, compiled by Frederick W. Horton. 12 pages, 8vo. Bulletin 48, The Selection of Explosives used in Engineering and Mining Operations, by Clarence Hall and Spencer P. Howell. 50 pages, illustrations, plates, 8vo. Bulletin 55, The Commercial Trend of the Producer-Gas Power Plant in the United States, by R. H. Fernald. 93 pages, illustrations, map, 8vo. Technical Paper 46, Quarry Accidents in the United States during the Calendar Year 1911, compiled by Albert H. Fay. 32 pages, 8vo. Washington, Government Printing Office, 1913.

Royal Institution of Great Britain, Weekly evening meetings: January 17, 1913—Some Further Applications of the Method of Positive Rays, by Prof. Sir J. J. Thomson. 9 pages, illustrations, plates, 8vo. January 24, 1913—Recent Advances in Scientific Steel Metallurgy, by Prof. John Oliver Arnold. 15 pages, illustrations, plates, 8vo. January 31, 1913—The Poetry and Philosophy of George Meredith, by George M. Trevelyan, Esq. 2 pages, 8vo. February 21, 1913—Horticultural Investigations at the Woburn Experimental Fruit Farm, by Spencer U. Pickering, Esq. 10 pages, 8vo. February 28, 1913—Active Nitrogen, by Professor the Hon. R. J. Strutt. 6 pages, illustrations, 8vo. London, Wm. Clowes & Sons, no date.

CURRENT TOPICS

The Heat Treatment of Gun-metal. ANON. (*Brass World*, ix, 4, 139.)—A paper by H. S. and J. S. G. Primrose, read before the British Institute of Metals. The gun-metal used consisted of a mixture like Government bronze, containing copper, 88 per cent., tin 10 per cent., and zinc 2 per cent. The physical tests are, tensile strength 31,360 pounds (14 tons) per square inch, and elongation 7.5 per cent. It is very difficult to obtain sound castings from this mixture which will stand a high water pressure. Although the castings may be free from blowholes, still they are not completely satisfactory when submitted to physical and hydraulic pressure. The results obtained were: (1) Tests show that no improvement may be expected from quenching, which lowers the strength of the material. (2) Simple annealing of the metal for 30 minutes very considerably increases its strength and elongation; the best results are obtained after annealing at 700° C. (3) The homogeneity and other physical properties of the metal are correspondingly improved, but particularly the capability of the castings to withstand hydraulic pressure. (4) These results are considered to be due to the removal of the eutectic from the microstructure, which after annealing shows only the crystals of a solid solution. (5) It is anticipated that this heat treatment will minimize corrosion difficulties.

Absorption of Gases by Charcoal. ANON. (*Eng.*, xciv, No. 2451, 846.)—The recent researches of Professor Dewar have drawn attention to the extraordinary absorptive power of charcoal, especially cocoanut charcoal, for gases, and now very extended use is made of this charcoal in gas and vacuum bulb researches. According to Prof. W. Hempel and Dr. G. Vater, the charcoal obtained by carbonizing blood is superior even to nut charcoal, and much depends on the temperature at which carbonization is effected. They investigated a great many other porous agents besides charcoal, such as Kieselguhr, pumice-stone, bog ore, spongy platinum, bone ash, and a great many elementary gases, as well as $CO_1CO_2CH_4$, C_2H_6, etc., at the temperatures 20° C., —78° C., and —185° C., and found that charcoal was superior to all others, and that a particular kind of blood charcoal, prepared by stirring commercial animal charcoal with blood and water to a rather stiff paste, was superior even to the nut charcoal. The best temperature for carbonizing both kinds of materials appears to be 600° C. Even with this particular blood carbon, the investigators failed to effect a complete separation of diatomic gases, though the adsorptive powers varied considerably for different gases.

V.
19

Units of Quantity of Radium Emanation. J. and G. DAUNE. (*Archives d'El Médicale*, xx, p. 521.)—The International Congress at Brussels in 1910 decided on a unit for RaEm, this unit being the amount of emanation in equilibrium with 1 gramme Ra and defined as a "curie." More convenient practical units for some purposes are the milli-curie and the microcurie, equal to 10^{-3} and 10^{-6} curie respectively. In terms of the older units, 1 curie $= 4.80 \times 10^{-5}$ gramme seconds, or 2.5×10^{9} maché units. [The gramme second is the amount of emanation produced by 1 gramme Ra per second. The Maché unit is the quantity of RaEm without disintegration products which produces a saturation current of 10^{-3} electrostatic units in a chamber of large dimensions.] Such units as a volt-hour, etc., which have often been used, have no meaning apart from the capacity of the particular instrument employed.

Magnetic Properties of Nickel and Manganese Steels. E. COLVER-GLAUERT and S. HILPERT. (*Faraday Soc. Trans.*, viii, 134.)—A series of nickel and manganese steels was investigated as to the influence of thermal treatment on their magnetic and metallographic properties, and the following are the conclusions arrived at. There is a distinct connection between thermal treatment and magnetic properties, but no definite connection between metallographic structure and the magnetic properties. Any modification which is produced by quenching these alloys from 1200° C. is in all cases strongly magnetic at room temperature; in the case of the 25 per cent. nickel steel, two superimposed temperature-hysteresis loops exist. Further, it is possible to define various constituents by their magnetic properties, and the metallographic structure of artificial nickel-iron alloys closely approximates that of meteoric iron. The allotropic theory of the magnetic properties of iron alloys is not supported by the facts.

Improving Noisy Gearing. ANON. (*Eng.*, xciv, No. 2448, 761.)—*Machinery* states that a simple method of lessening the noise of gearing has been found successful on a large scale in some St. Petersburg shops. For gears less than 18 inches in diameter two sheets of tin are fitted, one on each side of the wheel, so as to box in the space between the rim and the boss, the sheets being screwed to the rim. The space between the sheets is filled with sawdust and No. 4 shot, to eliminate vibration. When the diameter of the gears is greater than 18 inches, wooden rings are used instead of tin, attached in the same manner. A felt packing is used to prevent the sawdust leaking out. This arrangement not only reduces the amount of noise produced by the gearing, but it also has the advantage of closing the spaces between the spokes of the wheel, and so making it impossible for a workman to get his arms or tools caught in the wheel.

Photographic Recording of Ballistic and other Rapid Phenomena with the Aid of the Quenched Spark. C. CRANZ and B. GLATZEL. (*Deutsch. Phys. Gesell.*, xiv, 10, 525.)—After a brief review of the methods used earlier for recording photographically rapidly-occurring processes, such as ballistic phenomena, the authors describe their method, which enables a regular succession of pictures to be taken of a single bullet fired from a pistol, on a falling photographic plate. A direct current quenched gap (of the Scheller type using alcohol) is used, connected to 700-volt mains. The capacity in the gap circuit is made up of mica condensers variable from 25,000 to 600,000 centimetres; the inductance is kept very low. This inductance and that of the secondary (equal to 1800 centimetres) are in the form of flat spirals so as to secure very close coupling. In the secondary is a small spark-gap (used to illuminate the object to be photographed) shunted by a condenser. The exposures are made on a film which runs over two drums of 89 centimetres circumference, capable of making 9000 revolutions per second. It is found that the number of sparks passing can be adjusted accurately to any number between 200 and 100,000 per second by (1) altering the capacity in the primary circuit; (2) regulating the intensity of the current in the primary. Reproduced photographs show the method's capabilities. With 6400 sparks per second, the firing of a shot at a piece of wood is seen in all its phases. With 10,000 sparks per second, the movements of the cartridge in the operation of an automatic pistol can be followed. Other records show the bullet issuing from the muzzle, and the accompanying phenomena, taken with spark frequencies of 56,200, 72,000, and 92,200 per second. The possible application of this method to investigate electric double refraction is also mentioned.

Influence of Oxygen on the Properties of Metals and Alloys. E. F. LAW. (*Inst. of Metals Journ.*, viii, p. 222.)—Attention is drawn to the great influence exerted by oxygen when present in metals and alloys. Although recognized by practical men, the scientific side of the question has been neglected. It is pointed out that a chemical analysis of copper which failed to report 0.1 per cent. of lead would be considered unsatisfactory, yet it frequently happens that ten times as much of cuprous oxide is not reported. The omission is more serious than it appears at first sight, because the oxides, having lower specific gravities than the metals, occupy a larger volume, and the influence exerted by an impurity depends upon its volume and not on its weight. From cases examined, it appears that metallic oxides are insoluble, or practically insoluble, in metals and alloys, and occur as particles varying in size and distribution, entangled and embedded in the metal. Photomicrographs are given illustrating the pressure of oxides in bearing bronze, arsenical copper from a locomotive fire box, and also a

series to show the effect of increasing additions of arsenic to oxidized copper. As regards the effect of the presence of oxides on mechanical tests, the minimum effect is produced when the oxide occurs in the massive form, and the maximum effect when the oxide occurs as a network between the crystals. Abnormal corrosion of metals, also pitting and local deterioration, etc., are, in most cases, due to the presence of non-metallic impurities, and in all investigations of corrosion the presence of oxides must be taken into account.

New Prussian Regulations for Inks. F. W. HINRICHSEN. (*Chem. Zeit.*, xxxvii, 265.)—According to the new Prussian regulations for 1912 inks are classified into (1) "documentary" and (2) "writing inks," the latter being subdivided in (*A*) iron-gall inks, and (*B*) logwood and dyestuff inks. (1) A "documentary" ink is defined as an iron-gall ink which gives dark writing after 8 days' exposure to light and air. It must contain at least 27 grammes of anhydrous gallotannic and gallic acids and 4 grammes of iron (calculated on the metal) per litre. On the other hand, the amount of iron must not exceed 6 grammes, so that the ratio of gallotannic and gallic acids to iron must lie within the limits 4.5 : 1 and 6.75 : 1. The ink must not alter for at least 14 days in the inkpot, and must flow readily from the pen. The writing done with it must not be sticky immediately after drying, and after 8 days it must remain deep black when washed with water and with alcohol of 85 and 50 per cent. (2) Iron-gall "writing inks" (*A*) must contain at least 18 grammes of gallotannic and gallic acids, and at least 2.6 and not more than 4 grammes of iron (ratio 4.5 : 1 and 6.75 : 1). In other respects they must comply with the requirements of "documentary" inks. Inks of group *B* are not officially tested. Then follow the methods prescribed for the analysis of the inks.

Iron and Nitrogen. J. H. ANDREW, M.Sc. (*Eng.*, xciv., No. 2451, 860.)—This most interesting paper is supplied with diagrams and photomicrographs, showing the effect of the nitrogen absorbed by iron. The conclusions arrived at are: Iron and iron-carbon alloys absorb small amounts of nitrogen when melted under a high pressure of the gas. The absorption of 0.3 per cent. of nitrogen entirely suppresses the critical changes occurring in pure iron, and prolonged heating *in vacuo* is required to denitrogenize the metal. The absorption of 0.25 per cent. of nitrogen by a 0.6 per cent. carbon steel lowers the Ar 1 point to a marked degree. Such a nitrogenized steel can only be restored to the normal state of a pure steel by several weeks' heating *in vacuo*. It is considered that the critical changes occurring in iron and steel are due to the coalescence of like molecules, and that this coalescence is due to the contraction of the metal during cooling, bringing the molecules

sufficiently near together for the force of the molecular attraction of like molecules to exert itself and overcome the influence of the intervening molecules. The absorption of nitrogen, followed by the formation of iron nitride, prevents the iron molecules and the iron carbide molecules from coalescing with molecules of their own kind by keeping them farther apart. This will necessitate greater contraction of the metal, and therefore a lower temperature, before the like molecules are brought sufficiently near together for the force due to molecular attraction to effect a change. The effect of nitrogen upon the mechanical properties is made evident by considerations of its influence upon the critical change. Hydrogen has no influence upon the critical changes when introduced into the liquid metal under pressure. The influence of nitrogen upon the mechanical properties is the increase in tenacity and hardness and the decrease in elongation; this is readily understood when it is shown that nitrogen tends to retain the iron in the gamma state and the carbide in solution. The small specimens dealt with were intensely hard and brittle, the samples with a higher carbon content being more so than those containing only a small percentage of carbon. A most remarkable feature is the exceedingly small amount of nitrogen necessary to cause a great effect, and the difficulty in extracting the last traces of the gas from the metal. Iron nitride is not, therefore, the unstable compound that it is generally supposed to be. It appears necessary to remelt the nitrogenized iron in order to extract the gas.

The Yellow Discoloration of Paper. VIKTOR SCHORLLER. (*Wochbl. Papierfabr.*, xliii, 3222.)—Papers containing mechanical wood pulp discolor very readily with age, and papers containing straw and esparto pulp are subject to discoloration. Chemical wood pulp turns yellow to a less degree, while paper made entirely from rags suffers slight discoloration. The coloring may be due to: (1) destruction of the ultramarine or other blue color used in the manufacture; (2) actual yellowing of some component of the paper. The color of ultramarine may be destroyed by atmospheric oxidation or by acid residues in the paper, causing the sheet to return to its natural yellow color. There may also be discoloration from external causes, such as exposure to coal-gas, etc. The liability of a paper to discolor may be determined by: (1) allowing to lie in the dark for at least one year; (2) exposing to action of air and light for about one week; (3) heating under uniform moisture conditions at 95° C. for 3, 15, and 30 hours. The intensity of color developed by warming indicates the discoloration to be expected when the paper has aged. Unsized, unbleached cotton or linen half-stuff shows no tendency to discolor. Moderately-bleached stock, washed immediately after bleaching, does not discolor, but overbleached stock, or one that has been allowed to rest in the

V.
19

drainer for even one day before washing, will turn yellow with age. This is due to the oxidation of the cellulose fibres. The most important cause of the discoloration of paper is the rosin size. All rosin-sized papers turn yellow. This may be due to: (1) the reagent used to precipitate the size; (2) formation of rosin-iron compound; (3) oxidation of the rosin by atmospheric oxidation; (4) auto-oxidation, or polymerization of the rosin. The precipitant used has little effect on discoloration. Experiments showed that papers sized with rosin precipitated by commercial aluminum sulphate, acetic acid, magnesium sulphate and acetic acid, carbonic acid, alum, hydrochloric acid, and from alcoholic solution by water, turned yellow on heating to the same extent. Comparative tests showed that within the limits of commercial practice the presence of iron or of iron resinate has little effect on the coloration of paper. Nevertheless, care must be taken to use an alum low in iron. Discoloration due to the action of atmospheric oxidation on rosin is very slight in all cases, but rosin develops a darker color on standing, due to polymerization or auto-oxidation, and it is to this fact that the discoloration of rosin-sized papers is chiefly due. By previous treatment of the rosin with bleaching-powder this polymerization may be effected, and size made from rosin so treated has no effect on the discoloration of paper.

Reactions Accompanying the Osmosis of Hydrogen through Iron. G. CHARPY and S. BONNEROT. (*Comptes Rendus,* clvi, 394.)—Experiments on the osmosis of hydrogen through iron show that the gas is not absorbed by the metal, for the volume of gas extracted by heating *in vacuo,* even after prolonged passage of hydrogen, is found to be generally less than that obtained before osmosis, and hence it is concluded that iron and steel which have been manipulated without special precautions, in contact with air, are as a rule saturated with hydrogen. This is explained on the supposition that the nascent hydrogen, continuously produced on the surface of the metal each time it is heated, from the reaction with atmospheric moisture, immediately penetrates the metal. As might be expected, therefore, the properties of iron are not sensibly affected by the osmosis of hydrogen unless after a very prolonged passage of the gas, when the metal gradually softens. This is due to the reducing action of the hydrogen, which removes such impurities as phosphorus and sulphur as hydrides; desulphurization is especially marked. Carbon monoxide is generally present in the gas after osmosis, due to the action of water vapor (formed by the reduction of oxidized substances present in the metal) on the carbon or iron carbide also present, and hydrocarbons are formed by the direct action of hydrogen on iron carbide. The reducing action of hydrogen is quite distinct at 700° C. and increases rapidly with the rise of temperature, so that osmosis may be used as a means

for getting rid of the last traces of certain impurities from iron; and it is pointed out also that modification by hydrogen must go on in any ferrous metal which is submitted to successive heating and cooling. It is considered that hydrogen probably plays an important part in connection with many changes which may be effected in the solid metal and which must often be accompanied by the absorption or elimination of hydrogen.

Petroleum Production in the United States. ANON. (*Board of Trade J.*, Feb. 27, 1913.)—The preliminary estimates place the production of petroleum in the United States in 1912 at 220,200,000 barrels (each of 42 United States gallons), valued at $150,000,000, or 68 cents per barrel, as compared with 220,449,301 barrels, valued at $134,044,752, or 61 cents per barrel, in 1911. The year 1912 is the first year since 1859 in which the quantity produced has not shown an increase. The California output of low-grade oil reached 87,000,000 barrels, an increase of about 6,000,000 barrels over last year's figures. This increase was counterbalanced by the decreased production in the high-grade fields, with the exception of West Virginia, where the production increased by about 2,000,000 barrels. Oklahoma and Illinois still maintain their position in the high-grade field, as they are jointly responsible for about two-thirds of the total output. Last year, however, showed a decline in Oklahoma, as the average for the year was only 50 barrels per well, compared with 73.4 barrels in 1911. No new States were added to the list of producers in 1912, but Wyoming and Michigan, hitherto only small producers, gave promise of becoming of greater importance. With the exception of California, where overproduction and other causes made prices very low, the price of crude oil steadily advanced throughout 1912. This rise was due to fundamental conditions and not to manipulation. Last year production remained steady, while consumption increased so as to result in a shortage, and prices would have gone even higher but for the surplus for previous years in store. The price of very high grade Pennsylvania oil rose from $1.35 to $2.00 per barrel at the well. In the year 1912 there was a marked increase in the number of independent oil refineries, especially in Illinois and Oklahoma.

Machine Mining of Coal. ANON. (*Amer. Mach.*, xxxviii, 9, 340.)—The coal report for 1911, recently issued by the United States Geological Survey, throws an interesting light on the improved methods of coal mining. In 1911, 13,819 machines were used in mining coal, 565 more than in 1910. The leading coal-producing State is Pennsylvania, and it also leads in the total tonnage mined by the use of machines, and in the number of machines used; but Ohio outranks all other States in the proportion of machine-mined coal to the total output.

Heating Effect of Radium. E. RUTHERFORD and H. ROBINSON. (*Eng.*, xciv, No. 2442, 549.)—Professor Rutherford states that a large amount of work has been done on this problem since Curie's time, but they were still uncertain as to two fundamental questions: Was the energy of the radiations a measure of the heating effect, and was the heating due to the α particles, the chief product, or also to other products? Radium and RaA gave α particles, RaB gave β and γ particles, and RaC gave α, β, and γ particles. There might be disintegration before the ejection of the α particle, and also rearrangement of the residual atom after the ejection. Geiger had shown that there was a relation between the rate of decay and the velocity of expulsion. In his new measurements he had applied his own and Barnes's method, using a differential water calorimeter. The tube containing the emanation was placed within a platinum coil and the galvanometer current was balanced. When the calculations were first made on the assumption that the heating was all due to α particles, it was found that the α particles alone could not account for the full heat effect. Experiments were then made to separate the effect of the β and γ particles from the α particles by the aid of very fine glass tubes placed in mercury within the calorimeter. There was uncertainty both as to the measurements and the standards, and they did not exactly know what they measured; but the results agreed with those of Meyer and Hess, and they indicated that the heating effect of radium agreed with the energy of the radiation, except that there was a slight deficiency as to RaC, which was known to emit γ rays of great velocity.

Relations between the Macrostructure and Crystallization of Steel. N. T. BELAIEW. (*Rev. de Métallurgie*, ix, 647.)—From a long series of observations of the macrostructure of ordinary and alloy steels, and an examination of the developed crystals often found in the pipes and cavities in ingots, it is concluded that cast steel is composed, both externally and internally, of crystals similar to those developed in the pipes and cavities. The size, shape, and distribution of the crystals depend upon the mass, section, and composition of the ingot and also upon the method of cooling, etc. These crystals are produced during the period of solidification, and their formation is revealed by the macrostructure, which is a result of irregularities in composition and is typical for all classes of steel. In general, the macrostructure cannot be modified at the temperatures attained in the course of ordinary thermal or mechanical operations, so that it really represents the stable structure of the steel. Cold mechanical work only produces deformation of the crystals, while hot treatment only produces local changes in each of the particles constituting the macrostructure. Consequently the difference between the three types of steel is: (1) Cast steel is made up of crystals of various shapes and sizes, arranged hap-

hazard; (2) mechanically-worked steel consists of the same crystals more or less displaced, according to the nature and degree of working; and (3) thermally-worked steel is always made up of the same primitive crystals, either in their natural or deformed state, but the constituent parts of the crystals have been altered as a result of equilibrium changes determined by temperature and other conditions of the thermal treatment.

The Physico-chemical View of the Staling of Bread. J. R. KATZ. (*Z. Elektrochem.*, xix, 202.)—The view is advanced that the change from fresh to stale bread is a reversible transformation, stale bread being the form stable at low temperatures, 0° to 25° C., and fresh bread stable at higher temperatures, 50° to 100° C. No exact transition point can be determined. Fresh bread can be preserved in liquid air, on account of the very low speed of transformation at low temperature. On the basis of these experiments it is suggested that bread may be kept fresh, and night work in bakeries avoided, either by storage at 60° to 100° C., or in a refrigerating chamber.

Zirconium. E. WEDEKIND. (*Annalen*, cccxcv, 149.)—The preparation of metallic zirconium by means of magnesium or by the alumino-thermic method was unsatisfactory, but good results were obtained by a method devised by the author and H. Kuzel. Pure zirconium oxide was intimately mixed with an excess of metallic calcium as finely divided as possible. The mixture was placed in an iron tube which was exhausted to about 0.5 to 0.1 mm. The bottom of the tube was heated with a blowpipe till the reduction began, after which the tube was cooled by blowing air on it and finally dipping in water. When quite cool the contents were rapidly pulverized and treated first with water which had been boiled and cooled, next with acetic acid, finally with very dilute hydrochloric acid. Air should be excluded during the whole of the treatment. The residue was finely powdered and again digested with boiled dilute hydrochoric acid. The powder was filtered off and washed with air-free water till the spectroscopic calcium reaction was no longer given. The water was removed by acetone and the powder dried in an exsiccator at ordinary temperature and then dried in a high vacuum at 250° to 300° C. The portion for analysis was further dried in a completely exhausted porcelain tube at 800° to 1000° C. This was done in a small kryptol furnace. A regulus was thus obtained which on filing and polishing gave a fine metallic surface which did not oxidize in air. The yield was about 97.5 per cent. The metal contained 97.7 per cent. of free zirconium. The specific gravity of the powder at 18 °C. was 5.98 and of the fused (sintered) metal at 17.5° C., 6.204. The metal was completely melted (not sintered) by making an arc between zirconium electrodes *in vacuo* in the Weiss-Neuman furnace. The specific gravity of the completely melted product was 6.44 at 16° C. The calcium

method has been applied to other refractory metals,—*e.g.*, titanium, thorium, tantalum, etc. The melting point of this titanium was 1530° C., according to G. K. Burgess and 2350° C. according to v. Bolton. Burgess melted the metal on platinum, but his method has given good results with iron, chromium, etc., and it is probable that v. Bolton's result is too high, owing to the formation of zirconium oxide, with a melting point of about 2500° C. A sample of zirconium hydride, considered to have the formula ZrH_4, was found to contain some oxide, and the formula ZrH_2 was found for the hydride. The oxide obtained on oxidation does not appear to be ZrO_2, nor does it correspond to the suggested Zr_2O_3. A new compound, the nitride, Zr_3N_2, was obtained by heating the metal in nitrogen at 1050° C. On passing hydrogen over the nitride for 15 minutes at 1050° C., 8.7 per cent. (87 per cent.?) of the theoretical yield of ammonia was obtained. The so-called amorphous zirconium was obtained by Berzelius's method by heating potassium zirconium fluoride with potassium in an iron tube. On heating this powder it often becomes pyrophoric. It contains only about 35 per cent. of free zirconium. Its characteristic feature is its great surface; it is like a colloidal gel and retains water with great tenacity. With acids it easily passes into a hydrosol. The hydrogel precipitated from this hydrosol is very similar to the amorphous ziroconium.

Emission of Charges in Vacuo. E. HENRIOT. (*Le Radium*, ix, 224.)—Two elements, potassium and rubidium, are clearly distinguishable, by a radiation analogous to that from radioactive bodies, from ordinary substances whose activity is doubtful. Potassium emits β-rays approximately homogeneous and easily deviable, with a penetrating power about equal to that of the β-rays from uranium; this radiation is normal, atomic, and spontaneous. Rubidium emits slower β-rays, fairly homogeneous, with a penetrating power about equal to that of the β-rays from radium, with general characters like those of the rays from potassium. Potassium, rubidium, and their salts emit, spontaneously *in vacuo*, electrical charges, a great part of which, at any rate, must be attributed to ionizing β-rays.

Swedish Electric Current for Denmark. ANON. (*Eng.*, xciv, No. 2451, 862.)—Some time ago we mentioned the plan of exporting electric current from the Swedish State power station at Trollhättan to Denmark. This plan has not been abandoned, but a new scheme has been brought forward. The three falls—Skapanäsfors, Skagfors, and Atrafors, situated near each other on the river Atra—are now proposed as the source of power. They have been secured for this purpose and are calculated to yield some 17,600 horsepower locally, or 14,900 horsepower at the boundary of Copenhagen. The distance between this projected station and Copenhagen is only about half that between Trollhättan and the

capital of Denmark. The entire installation, including those at Copenhagen, is estimated to cost $1,500,000.

New Method of Revealing Segregation in Steel Ingots. R. HADFIELD. (*Iron and Steel Inst. Journ.*, lxxxvi, 40.)—The method consists in pouring a little molten copper on the top of the ingot soon after pouring. If the copper is added before solidification is complete it displaces the residual molten steel, but if added after complete solidification it fills up the cavities and shows the areas of segregation. This method seems to open up a valuable source of information on the rates of cooling, segregation, and liquation, and the present results indicate that the interior of an ingot remains hot for a much longer period than was previously thought, thus providing greater opportunities for segregation.

Production of Iron and Steel in France During 1912. ANON. (*Board of Trade J.*, Feb. 20, 1913.)—According to the Bulletin of January 21, 1913, of the "Comité de Forges de France," the amount of iron and steel produced in 1911 and 1912 by the members of the association was as follows:

	Metric tons.	Metric tons.
Pig iron	4,426,469	4,826,553
Steel ingots	3,680,613	4,136,942
Steel products:		
Blooms and billets	1,744,148	2,064,072
Merchant steel	709,131	675,259
Girders and shapes	621,249	641,720
Rails	449,818	492,767
Sheets and plates	449,234	501,859
Other products	409,052	444,013

Coating Iron with Aluminum. S. UYENO, Tokio. (*Eng. Pat.* 11,836, of 1912.)—The iron article to be coated is first galvanized or tinned, and is then immersed in molten aluminum at about 700° or 800° C., and during the immersion the surface is swept by steel brushes. The tin or zinc passes into the molten aluminum, and aluminum replaces it on the iron surface. The article is treated in this manner in two or more of such baths, and the greater part of the tin or zinc is left in the first bath. It is claimed that this process causes the aluminum to adhere to the surface of the iron so well that it will not come off, nor tarnish, nor corrode under the action of air, water, or heat, and cannot be stripped off by mechanical means.

The Specific Heat of Wood. F. DUNLAP. (*U. S. Dept. of Agric.*, Bull. No. 110.)—The specific heat of a large number of samples of wood was observed by the aid of a Bunsen ice calorimeter specially adapted for the work. These samples were ovendried at 105° C., and most of the observations were made between

this temperature and 0° C. Tables are given of the detailed results; the mean specific heat of oven-dried wood is 0.327, and this is nearly constant for all kinds of wood. There is practically no variation in samples taken from different parts of the tree, and the location where the wood is grown makes no practical variation. There is a large variation in specific heat with the temperature, however, and when represented by a straight line formula the specific heat is expressed by the following equation: Specific heat $= 0.266 + 0.00116\,t$.

Sources of Supply for the Manufacture of Paper. C. BEADLE and H. P. STEVENS. (*J. Roy. Soc. Arts,* lxi, 347.)—Alluding to the supply of pulp wood, particularly in the United States, showing material signs of exhaustion, the authors then review the recent investigations of proposed new sources of supply. They consider chiefly the investigations carried out by the United States Forest Service at Wausaw on the utilization of coniferous woods of inferior quality; Raitt's investigations on bamboo; cottonseed hull fibre; bagasse, particularly the McMullen process of shredding as carried out in Cuba; Brand's investigations on American crop plants, and finally to their own experiments with *Hedychium coronarium*. The extraordinary development of this plant in Brazil is described, and also the experiments carried out with plants grown at Kew. The papers prepared from Hedychium fibre are among the strongest hitherto recorded, equal or superior to the best manila papers, and are particularly suitable for the manufacture of paper yarns for textile purposes. The following table was compiled to give a comparative survey of the possible importance of the principal new paper-making materials undergoing development:

Plant.	Acres under cultivation.	Tons per acre per annum of dry raw material.	Tons of raw fibre per annum on total area.	Percentage yield of pulp on dry raw material.	Tons of pulp per annum per acre.	Tons of pulp per annum on total area.
Cropped once a year:						
1. Corn stalks	30,000,000	1.0	30,000,000	12–18	0.12	3,600,000
2. Broom corn	178,000	3.0	450,000	32–40	1.00	150,000
3. Rice straw	720,000	2.0	1,500,000	35	0.70	500,000
4. Flax straw	2,000,000	1.0	2,000,000	30	0.30	600,000
5. Cotton hull fibres	....	....	150,000	75	....	112,000
6. Cotton stalks	10,000,000	0.45	4,500,000	35–40	0.15	1,500,000
7. Hemp straw	....	5.0	....	20	1.00	....
8. Hedychium	....	6–10	....	60	4.00	....
Cropped every 5 years:						
9. Bamboo (Sindall)	....	15/5	....	45 / 10	1.35	....
10. Bamboo (Raitt)	....	8/5–18/5	....	45	1.57	....
Cropped every 40 years:						
11. Wood pulp	....	16 cds / 40	....	4	0.20	....

Alloys for Casting. F. DE BUIGNÉ, Magdeburg. (*Eng. Pat.* 1346, of 1912.)—Type-metal alloys designed for casting under pressure should be capable of remaining in the molten condition for a long time without changing in composition, and should not form dirt or dross in the casting channels or moulds. Alloys composed of aluminum, copper, and tungsten, and free from zinc, fulfill these conditions. Alloys which give satisfactory results are (1) aluminum 80 to 90, copper 8 to 10, tungsten 1 to 10 parts, and (2) copper 90 to 95, aluminum 3 to 10, tungsten 0.1 to 5.0 parts. Both alloys must be free from zinc.

Production of Mirrors by Cathodic Disintegration. G. RUMELIN. (*Physik. Zeits.*, xiii, 1222.)—The plate upon which the mirror is to be produced is used as the anode and is placed on a small table in juxtaposition to a plate of the metal to be disintegrated, which serves as a cathode, all being enclosed in a glass bell resting on a ground-glass plate. The space is first exhausted, then a current of hydrogen is sent through by the help of a Gaede pump. An opaque silver mirror can be produced in 30 seconds. Mirrors of gold, silver, platinum, copper, nickel, iron, palladium, and iridium have been thus produced.

Porcelain Insulators for High-Tension Transmission Lines. J. LUSTGARTEN. (*Inst. Elect. Engin. Journ.*, xlix, 235.)—This article is a summary of past and present practice in the design, manufacture, and testing of porcelain insulators for high-tension work. The ordinary methods practised in England, Germany, and America are given, describing various types of pin insulators, and curves are shown of electric tests both in the dry and wet condition. Their protection from damage due to arcs is considered, with special reference to Nicholson's arcing rings and Hermsdorf's metal shed insulator. Where the pull is too great for the ordinary type of pin insulator, shackle insulators are used. Suspension insulators of various kinds are mentioned, including the interlink and cemented types, with drawings and photographs showing how they are liable to break down under high voltage. The electrical considerations in design, the distribution of potential gradient along the series, and means of protection against arcing effects are detailed. The methods used in various factories of setting insulators are given, including puncture tests and artificial precipitation tests. It is shown that these methods vary considerably, and a full outline of the present practice is given relating to typical methods in different countries. In conclusion, there are mathematical notes on the potential gradient and density of the electric charge on the surfaces of condensers with different kinds of dielectric. A discussion follows relating principally to matters affecting the design and testing of porcelain insulators.

INDEX TO VOL. CLXXV.

Acid amides in the soil, Behavior of (Jodidi), 245
Aëroplane design, Stress considerations in (Zahm), 601
Alaska, On the edge of (Stradling), 338
Atmosphere, On the physics of the (Humphreys), 207

Bancroft, Wilder D.: Chemical production of light, 129
Barograph, aëroplane. The measurement of the true static pressure in a moving fluid—Application to an (Zahm), 503

Book Notices:
Billiter, J.: Die elektrolytische alkalichloridzerlegung mit starren metallkathoden, 548
Davis, W. A., and S. S. Sadtler: Allen's commercial organic analysis, vol. 7, 548
Hatschek, E.: An introduction to the chemistry and physics of colloids, 548
Hurst, H. E., and R. T. Lattey: A text-book of physics, 662
Northrup, E. F.: Methods of measuring electrical resistance, 546
Penrose's Pictorial Annual, 1912–1913, 195
Price, W. B., and R. K. Meade: Technical analysis of brass and the non-ferrous metals, 545
Sauveur, Albert: The metallography of iron and steel, 193
Wysor, Henry: Analysis of metallurgical and engineering methods, 78

Camp Life in Philadelphia (Jennings), 338
Chemical production of light (Bancroft), 129
Coblentz, W. W.: Note on the construction of thermopiles for monochromatic illuminators, 497
Coblentz, W. W.: A radiometer attachment for a monochromatic illuminator, 151

Current Topics, 14, 42, 57, 58, 80, 150, 162, 168, 196, 272, 327, 328, 333, 384, 412, 419, 420, 428, 437, 482, 495, 496, 502, 510, 533, 534, 550, 551, 600, 614, 626, 647, 648, 654, 664

Disinfectants, Standardization of, Recent progress in the (Weiss), 615
Donald, James: Safety of life at sea, 15
Duncan, Robert Kennedy: Industrial fellowships, 43

Edge of Alaska (Stradling), 338
Education, Industrial fellowships (Duncan), 43
Egg-white, Electrical properties of (Northrup), 413
Electrical energy, The production and distribution of (Insull), 561
Energy, The production and distribution of (Insull), 561
Engineer, The, in the building of the republic (Randolph), 259

Franklin Institute:
Board of Managers, Annual report, 170
Board of Managers, Standing committees, 335
Committee on Elections and Resignations of Members, Annual report, 173
Committee on Endowment, Annual report, 180
Committee on Instruction, Annual report, 171
Committee on Library, Annual report, 181
Committee on Meetings, Annual report, 184
Committee on Museums, Annual report, 183
Committee on Publications, Annual report, 176
Committee on Science and the Arts, Proceedings, December 4, 1912, 69; January 8, 1913, 187; February 5, 1913, 337; March 5, 1913, 429; April 2, 1913, 537; May 7, 1913, 656

FRANKLIN INSTITUTE—*Continued*
Committee on Science and the Arts, Annual report, 185
Committee on Sectional Arrangements, Annual report, 178
Committee on Stocks and Finance, Annual report, 174
Library notes, 74, 190, 340, 432, 541, 659
Membership notes, 71, 189, 339, 431, 539, 657
Popular lecture: Camp life in Philadelphia (Jennings), 338
Popular lecture: On the edge of Alaska (Stradling), 338
Popular lecture: On the trail of the Spanish pioneers (Monsen), 657
School of Mechanic Arts, Annual report of the Director, 1912–1913, 535
Sections, proceedings of meetings, 70, 188, 337, 430, 538, 656
Standing committees, 336
Stated meetings, proceedings, December 18, 1912, 69; January 15, 1913, 169; February 19, 1913, 335; March 19, 1913, 429; April 16, 1913, 535; May 21, 1913, 655

Gyroscope, Engineering applications of the (Sperry), 447

HERR, H. T.: Recent developments in steam turbines, 91, 273, 385, 511, 627
HUMPHREYS, W. J.: On the physics of the atmosphere, 207

Illuminator, monochromatic, A radiometer attachment for a (Coblentz), 151
Industrial fellowships (Duncan), 43
INSULL, SAMUEL: The production and distribution of energy, 561

JENNINGS, W. N.: Camp life in Philadelphia, 338
JODIDI, SAMUEL L.: The behavior of acid amides in the soil, 245
JODIDI, SAMUEL L.: The chemistry of the soil nitrogen, 483

Light, Chemical production of (Bancroft), 129

Metals, Resistivity of a few (Northrup and Suydam), 153
Mildew in paints, Notes on the formation and inhibition of (Gardner), 59
MONSEN, FREDERICK: On the trail of the Spanish pioneers, 657

Navigation. Safety of life at sea (Donald), 15
New York City, The railway tunnels of (Noble), 343
NOBLE, ALFRED: The railway tunnels of New York City, 343
NORTHRUP, E. F.: A brief examination of the electrical properties of egg-white, 413
NORTHRUP, EDWIN F., and V. A. SUYDAM: Resistivity of a few metals through a wide range of temperature, 153

Paints, Mildew in (Gardner), 59
Physics of the atmosphere (Humphreys), 207
Publications received, 77, 192, 341, 435, 549, 663

Radiography, Some recent developments in (Snook), 1
Radiometer attachment for a monochromatic illuminator (Coblentz), 151
Railway tunnels of New York City (Noble), 343
RANDOLPH, ISHAM: The engineer in the building of the republic, 259
Resistivity of a few metals through a wide range of temperature (Northrup and Suydam), 153

Safety of life at sea (Donald), 15
SNOOK, H. CLYDE: Some recent developments in radiography, 1
Soil, Behavior of acid amides in the (Jodidi), 245
Soil nitrogen, The chemistry of the (Jodidi), 483
Spanish pioneers, On the trail of the (Monsen), 657
SPERRY, ELMER A.: Engineering applications of the gyroscope, 447
Static pressure, true, in a moving fluid, the measurement of the (Zahm), 503
Steam turbines, Recent developments in (Herr), 91, 273, 385, 511, 627
STRADLING, GEORGE F.: On the edge of Alaska, 338
Stress considerations in aëroplane design (Zahm), 601

V. 19

SUYDAM, V. A., and EDWIN F. NORTHRUP: Resistivity of a few metals through a wide range of temperature, 153

Thermopiles for monochromatic illuminators, Note on the construction of (Coblentz), 497
Tunnels, Railway, of New York City (Noble), 343
Turbines, steam, Recent developments in (Herr), 91, 273, 385, 511, 627

U. S. Bureau of Standards, Notes, 65, 163, 329, 421, 531, 649

WEISS, J. M.: Recent progress in the standardization of disinfectants, 615

ZAHM, A. F.: The measurement of the true static pressure in a moving fluid—Application to an aëroplane barograph, 503
ZAHM, A. F.: Stress considerations in aëroplane design, 601

PRESS OF
J. B. LIPPINCOTT COMPANY
PHILADELPHIA